ANNEX E

REPORTS PROVIDED BY RECOVER

TO SUPPORT THE

LOXAHATCHEE RIVER WATERSHED RESTORATION PROJECT

PROJECT IMPLEMENTATION REPORT

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EXECUTIVE SUMMARY

Annex E contains documentation of four reviews performed by the interagency REstoration COordination and VERification team (RECOVER) system-wide science team, per CERP Programmatic Regulations guidance. The reviews were:

- RECOVER System-Wide Evaluation: Loxahatchee River Watershed Restoration Project (LRWRP)
- RECOVER Consistency Review: Loxahatchee River Watershed Restoration Project (LRWRP) Project Goals and Objectives and Performance Measures
- RECOVER Consistency Review: Loxahatchee River Watershed Restoration Project (LRWRP) Adaptive Management Plan
- RECOVER Review of the Loxahatchee River Watershed Restoration Project (LRWRP) Draft Project Operating Manual (DPOM)

RECOVER SYSTEM-WIDE EVALUATION: LOXAHATCHEE RIVER WATERSHED RESTORATION PROJECT (LRWRP)

The REstoration COordination and VERification team (RECOVER) system-wide evaluation of Loxahatchee River Watershed Restoration Project (LRWRP) performance provides the evaluation required for all Comprehensive Everglades Restoration Plan (CERP) projects under the 2003 programmatic regulations. This report is a broad-scale evaluation of ecological effects of the LRWRP alternatives on the Northwest Fork of the Loxahatchee River and Estuary, the Loxahatchee Watershed, and Lake Okeechobee lake stage. The scope of the review covers all areas expected to be improved by LRWRP including areas outside of the LRWRP project boundary which fall within the overall CERP program area. The review includes the use of a broad range of evaluation tools, performance measures, and best professional judgment that reach beyond the tools and expertise of the traditional USACE planning process. The purpose of the review is three-fold: (1) to provide insight into whether some alternatives performed better ecologically than others; (2) to indicate whether alternatives may lead to unintended ecological conditions; and (3) to investigate the effects of LRWRP alternatives that could potentially conflict with the goals of CERP on a regional scale. The following key findings are provided:

System-wide Performance: All areas affected by LRWRP can be improved by the proposed alternatives. These areas include the Northwest Fork of the Loxahatchee River and Estuary within the Northern Estuaries, the Loxahatchee Watershed which bridges the Northern Estuaries, Lake Okeechobee, and the Greater Everglades (indirectly via natural resource use), while not impacting lake stage levels in Lake Okeechobee. Performance of alternatives regarding the Northwest Fork of the Loxahatchee River works disparately with performance of LRWRP alternatives regarding the Loxahatchee Watershed, most likely due to whether increased freshwater flow is reaching the Northwest Fork or is distributed within the watershed. ALT10 performs best for the Northwest Fork and worst for the Loxahatchee Watershed. ALT13 performs best for the Loxahatchee Watershed and worst for the Northwest Fork. ALT5R is the second best performing alternative for both the Northwest Fork and Loxahatchee Watershed (ALT2 is third best for both). Despite this observation all alternatives improve ecological and hydrological conditions in both the Northwest Fork and Loxahatchee Watershed.

Adaptive Management: There was a determination that proceeding with an adaptive management approach can further increase the benefits of LRWRP and positively influence the implementation of LRWRP. Adaptive management provides a means to learn during implementation and operations through monitoring and assessment in order to ensure restoration performance, while minimizing impacts and reducing risk overall. RECOVER will continue to participate in the drafting of the LRWRP Adaptive Management and Monitoring Plans and provide a consistency review upon finalization.

Full CERP Implementation Consistency: Because modeling resources and capability did not allow for full system-wide CERP runs, RECOVER was unable to provide a complete understanding of how LRWRP would function as part of full CERP implementation. LRWRP project features formulated to achieve incremental system-wide restoration benefits in the near-term may not function as well once all of CERP is implemented as envisioned in the Water Resource Development Act of 2000. This may require adapting project features to achieve the full set of restoration benefits stated under CERP as additional CERP projects are implemented. Nevertheless, the LRWRP project represents an important near term-incremental step towards restoration of the south Florida Everglades ecosystem.

Future CERP Increments: Future increments of CERP, as it relates to the restoration of the Loxahatchee River and Watershed, should focus on the need for more storage and connectivity to meet full CERP restoration goals for water quantity, quality, timing, and distribution to the river and throughout the watershed and associated Everglades regions discussed in this review.

Climate Change: The need for more reliable sources of storage may become more apparent as a result of anticipated changes in climate. The National Climate Assessment and Development Advisory Committee's National Climate Assessment 2014 final report identifies sea level rise, increasing temperatures resulting in an increase in frequency, intensity, and duration of extreme heat events, and decreased water availability as key messages regarding climate change in the southeast United States and Caribbean. These factors may lead to increased evapotranspiration rates, changes in rainfall intensity, seasonal timing, and amounts. Atlantic cyclone activity is also anticipated to increase. Future planning efforts should evaluate scenarios of these climatic drivers and regional stressors to determine plans that are robust enough to address climate variation. In addition, scientists and managers should continue monitoring and associated analyses to understand the effects of climate change on system-wide indicators that are envisioned to be restored under CERP.

Northwest Fork of the Loxahatchee River and Estuary: Modeling of the hydrology, salinity, and associated ecology of the Northwest Fork of the Loxahatchee River and associated Loxahatchee Estuary, showed an increase in freshwater flow throughout the Northwest Fork of the Loxahatchee River during both the wet and dry seasons. The increase in dry season freshwater flows ranged from 15% to 30% while the increase of wet season freshwater flows ranged from 20% to 22% across the LRWRP alternatives. Modeling also showed that the increase of freshwater flow throughout the Northwest Fork of the Loxahatchee River and Estuary had a notable positive influence in the "Flood Plain Swamp and Hydric Hammock in the Freshwater Riverine Flood Plain" Valued Ecosystem Component (VEC) while showing only modest improvements in the "Tape Grass, *Vallisneria americana*" VEC, "Fish Larvae in the Oligohaline Zone" VEC, and "Oysters in the Mesohaline Zone" VEC. Virtually no difference between the future without modeling scenario and project alternatives were noted in the modeling results for the "Flood Plain Swamp in the Tidal Flood Plain" VEC and "Seagrasses in the Polyhaline Zone" VEC (7 acre difference between FWO [727 acres] and worst performing alternative [ALT10 = 720 acres) for the Polyhaline Zone. Overall, ALT10 provides the

most improvement in freshwater flow and the most enhancement of salinity conditions throughout the VECs, as a whole, within the Northwest Fork of the Loxahatchee River and Estuary.

Loxahatchee Watershed: General improvement in watershed hydrology was observed in Flow Way 3 (3% - 30%) and Flow Way 1 (15% - 16%). Minimal improvement in watershed hydrology was observed in Flow Way 2 (1% - 3%). Model results indicated alternative performance for the Loxahatchee Watershed was opposite of alternative performance for the Northwest Fork of the Loxahatchee River and Estuary. Alternative 13 made the most improvement of LRWRP alternatives in the hydrology of the Loxahatchee Watershed outperforming the future without modeling scenario by 30% in Flow Way 1, 3% in Flow Way 2, and 15% in Flow Way 3. Where ALT10 performed best in the Northwest Fork, it performed the worst of all alternatives in regards to hydrology in the Loxahatchee Watershed, improving hydrology by 3% in Flow Way 1, 15% in Flow Way 2, and 1% in Flow Way 3. Connectivity within the Loxahatchee Watershed was improved by all LRWRP alternatives, ranging from scores of 0.46 (ALT10) to 0.83 (ALT13) compared to 0 for the FWO scenario.

Lake Okeechobee Lake Stage: LRWRP ALT10 includes construction of deep reservoir associated with C-51. This feature would reduce water deliveries, via the L-8 canal, from Lake Okeechobee to the LRWRP area. Analysis of outflows through the C-10A culvert into the L-8 canal were analyzed for their impact on Lake Okeechobee lake stage as if the discharges did not occur. The additional water volume in Lake Okeechobee resulting from the lack of discharge through the C-10A culvert into the L-8 canal scenario showed virtually no increase in Lake Okeechobee lake stage. The largest monthly average release (October 2013) in the past 10 years was 394.5 cfs which was equivalent to an average of 782.4 acre feet per day (24,254 acre feet per month). None of the other LRWRP alternatives in the final array contain features that would impact Lake Okeechobee lake stage.

RECOVER CONSISTENCY REVIEW: PROJECT GOALS AND OBJECTIVES AND PERFORMANCE MEASURES

The RECOVER team consistency review of the project goals and objectives and performance measures for LRWRP fulfilled three requirements as described by the 2003 programmatic regulations. Those requirements were: (1) ensure the project is consistent with CERP's goals and objectives; (2) document consistency of the project performance measures with RECOVER's system-wide performance measures; and (3) suggest improvements to the project performance measures with the intent of improving target or evaluation methods to better evaluate project alternative plans that, if pursued, would contribute to selecting a tentative plan with the best performance by the project in achieving ecosystem restoration goals. To address these requirements, the RECOVER consistency review team reviewed the project summary report and performance measures considered for utilization in LRWRP plan formulation. RECOVER determined the goals and objectives of LRWRP are consistent with the goals and objectives of CERP which are: (1) enhance ecological values and (2) enhance economic values and social well-being. The RECOVER consistency review team noted how up-to-date each performance measure was, how frequent each performance measure is used, and if it was a RECOVER approved performance measure. The performance measures utilized by LRWRP for plan formulation and assessment of LRWRP alternative plans were found to be appropriate tools for assessing project alternatives and for achieving project success.

RECOVER CONSISTENCY REVIEW: ADAPTIVE MANAGEMENT PLAN

In accordance with CERP Guidance Memorandum 40.02 and other relevant guidance (e.g., CERP Guidance Letter 12/06), RECOVER must review the Loxahatchee River Watershed Restoration Project (LRWRP) project level monitoring plan(s) in regards to consistency with the existing Monitoring and Assessment Plan (MAP 2009) to prevent duplication of monitoring activities. Additionally, in this review, RECOVER evaluates the need for project-level monitoring to fill temporal or spatial gaps for parameters monitored in the MAP 2009 in order to evaluate project-level effects. As projects are typically not at the construction stage when this Review is prepared, and that a variety of changes may occur between now and operational readiness of the Project, this review, when completed, should be considered an interim document. Future developments may require modification of monitoring plans and/or revision of this Review. This document provides RECOVER's comments and recommendations to the Project PDT regarding incorporation of proposed monitoring into the project.

This statement documents recognition that the LRWRP Adaptive Management Plan and Monitoring Plans are in draft and will undergo updates in the future. It is recommended that a detailed review of the Adaptive Management Plan and Monitoring Plans be performed by RECOVER, when these documents are finalized, in order to gain input from scientists who possess most current system-wide scientific knowledge. RECOVER will continue coordination with the U.S. Army Corps of Engineers and the South Florida Water Management District as requested.

RECOVER REVIEW OF THE LOXAHATCHEE RIVER WATERSHED RESTORATION PROJECT (LRWRP) DRAFT PROJECT OPERATING MANUAL (DPOM)

The 2003 CERP Programmatic Regulations (33 CFR Part 385.26(c)) provides for, but does not require, a RECOVER review of the Project Operating Manual. This statement documents recognition that the LRWRP operating manual is in draft and will undergo updates in the future. It is recommended that a detailed review of the DPOM be performed by RECOVER near the end of the project design phase, in order to gain input from scientists who possess most current system-wide scientific knowledge. RECOVER will continue coordination with the U.S. Army Corps of Engineers and the South Florida Water Management District during future LRWRP project operations manual updates as requested.

Table of Contents

E INTRODUCTION 3
E.1 Background and Purpose 3
E.2 LRWRP Goals and Objectives 3
E.2.1 Model Assumptions and Project Alternatives 4
E.2.2 Performance Measures 13
E.2.3 Uncertainty 14
E.2.4 Evaluation Process and Organization 17
E.3 NORTHWEST FORK OF THE LOXAHATCHEE RIVER AND ESTUARY 18
E.3.1 Introduction 18
E.3.2 Performance Measures and Evaluation Approach 20
E.3.3 Evaluation 21
E.3.4 Summary and Conclusions 31
E.4 LOXAHATCHEE WATERSHED 33
E.4.1 Introduction 33
E.4.2 Performance Measures and Evaluation Approach 36
E.4.3 Evaluation 38
E.4.4 Summary and Conclusions 47
E.5 LAKE OKEECHOBEE LAKE STAGE 48
E.5.1 Introduction 48
E.5.2 Summary and Conclusions 51
E.6 Overall Rankings of LRWRP Alternatives 51
E.7 RECOVER EVALUATION 51
E.7.1 RECOVER Regional Evaluation Team 51
E.7.2 RECOVER Executive Committee Review 52
E.8 REFERENCES 53
E.9 SUPPLEMENTAL INFORMATION 56
E.9.1 Dry Season Scoring Maps for VEC Zones (excluding Riverine Flood Plain) 56
E.9.2 Wet Season Scoring Maps for VEC Zones (Excluding Riverine Flood Plain) 61
E.10 RECOVER CONSISTENCY REVIEW: LOXAHATCHEE RIVER WATERSHED RESTORATION PROJECT (LRWRP) PROJECT GOALS AND OBJECTIVES AND PERFORMANCE MEASURES 67
E.10.1 RECOVER Consistency Review 67
E.10.2 LRWRP Eco-subteam Response to RECOVER Consistency Review 72
E.11 RECOVER CONSISTENCY REVIEW: LOXAHATCHEE RIVER WATERSHED RESTORATION PROJECT (LRWRP) ADAPTIVE MANAGEMENT AND MONITORING PLANS 86

E.12 RECOVER REVIEW OF THE LOXAHATCHEE RIVER WATERSHED RESTORATION PROJECT (LRWRP) DRAFT PROJECT OPERATING MANUAL (DPOM) 87

List of Tables

Table E-1: CERP Goals and Objectives.....3
Table E-2: LRWRP Goals and Objectives 4

Table E.2-1: Success of LRWRP Alternatives Achieving Flow Restoration Targets for the Wet Season and Dry Season to the NWFLR. 21
Table E.2-2: Average Daily Flow to the NWFLR (cfs) Regardless of Season. 22
Table E.2-3: Percentage of Flow to the NWFLR Based on Average Daily Flows (Regardless of Season). 23
Table E.2-4: Wet Season Average Daily Flow to the NWFLR (cfs).....24
Table E.2-5: Percentage of Flow to the NWFLR Based on Wet Season Average Daily Flows. 25
Table E.2-6: Dry Season Average Daily Flow to the NWFLR (cfs). 26
Table E.2-7: Percentage of Flow to the NWFLR Based on Dry Season Average Daily Flows. 26
Table E.2-8: Salinity Performance Results from Performance Measure 1.....28
Table E.2-9: Riverine Flood Plain Scoring Using 30 Day Rolling Average (Dry Season).....28
Table E.2-10: Habitat Units (Acres) for Each VEC where Salinity Restoration Targets Were Met.....29
Table E.2-11: Percentage of VEC Acreage where Salinity Restoration Targets Were Met. 29
Table E-2-12: PM1 Scoring Rubric for Objective 2 (USACE and SFWMD 2015). 32
Table E.2-13: Ranking of LRWRP ALTs Performance for PM1.....33

Table E.3-1: Ranking of LRWRP ALTs Performance for PMs 4 and 9. 48

Table E.4-1: Outflows (cfs) through the C-10A Culvert into the L-8 Canal over the Past Ten Years....49
Table E.4-2: Additional Volume (Acre-Feet) of Water in Lake Okeechobee if Outflows through the C-10A Culvert into the L-8 Canal Did Not Occur.....50

Table E.5-1: Overall Ranking of LRWRP Alternatives Based on Performance.....51

Table E.6-1: RECOVER Regional Evaluation Team.....51
Table E.6-2: Members of the REC who Reviewed this RECOVER Regional Evaluation. 52

List of Figures

Figure E-1: Orientation of Three Flow Ways within the Loxahatchee Watershed. 9
Figure E-2: LRWRP Alternatives 2 and 5.....11
Figure E-3: LRWRP Alternatives 10 and 13. 12
Figure E-4: LRWRP Alternative 5R (Revision of LRWRP ALT5). 13
Figure E-5: Sea Level Trends at Lake Worth Pier since 1900 (NOAA). 17
Figure E.2-1: Map of the Loxahatchee River and Estuary. 18
Figure E.2-2: Lainhart Dam at 15 cfs (pre-2018). 19

Figure E.2-3: Masten Dam during higher flows (pre-2018). 19
Figure E.2-4: Contribution of Average Daily Tributary Flows to the NWFLR for the 41 POR (1965-2005).....22
Figure E.2-5: Wet Season Contribution of Average Daily Tributary Flows to the NWFLR (1965-2005).....24
Figure E.2-6: Dry Season Contribution of Average Daily Tributary Flows to the NWFLR (1965-2005).....25
Figure E.2-7: Correlation between Salinity Event Ratio Ds/Db (>1 ppt) and River Mile.....27
Figure E.2-8: Comparison of LRWRP alternative wet season average daily flow compared to the FWO. 31
Figure E.2-9: Comparison of LRWRP alternative average dry season daily flow compared to the FWO. 31

Figure E.3-1: The LRWRP Project Area. 34
Figure E.3-2: The map on the left shows the landscapes of the predrainage Everglades and bordering areas. The map on the right shows the directions of surface water flow under predrainage conditions. The red box indicates areas relevant to the LRWRP. Maps are modified from McVoy et al. 2011.....35
Figure E.3-3: Indicator regions within the Loxahatchee River Watershed. 37
Figure E.3-4: Scores for Watershed Hydrology PM.....38
Figure E.3-5: Scores for Watershed Hydrology PM by flow way. 39
Figure E.3-6: Stage Duration Curves for Indicator Regions in Western FW2. 40
Figure E.3-7: Scores for Connectivity PM. 41
Figure E.3-8: Scores for Each Criterion for Each Alternative. 42
Figure E.3-9: Criteria Combined by Flow Way. 42
Figure E.3-10: Stage Duration Curve for Indicator Region CM-1. 43
Figure E.3-11: Scores for the Total Watershed. 43
Figure E.3-12: Species Occurrence within the LRWRP and Adjacent Areas.....45
Figure E.3-13: Sampling Locations for Aquatic Fauna in the Everglades and Adjacent Areas from 2005-2006.....46
Figure E.3-14: Average Standing Crop per Region of Aquatic Fauna Prey Population during the 2005 Late Wet Season, Broken Down by Taxonomic Category (Trexler and Robertson 2006). 47

Figure E.4-1: October 2013 Monthly Departure from Normal Precipitation (Griffin and Zierden 2013).....50

Figure E.8-1: Map of Dry Season Scoring of LRWRP Alternatives in the Tidal Flood Plain VEC. 57
Figure E.8-2: Map of Dry Season Scoring for LRWRP Alternatives for the Vallisneria VEC.....58
Figure E.8-3: Map of Dry Season Scoring for the Oligohaline Zone VEC.....59
Figure E.8-4: Map of Dry Season Scoring for the Mesohaline Zone VEC. 60
Figure E.8-5: Map of Dry Season Scoring for the Polyhaline Zone VEC. 61
Figure E.8-6: Map of Wet Season Scoring for the Tidal Flood Plain VEC. 62
Figure E.8-7: Map of Wet Season Scoring for the Vallisneria VEC. 63
Figure E.8-8: Map of Wet Season Scoring for the Oligohaline Zone VEC. 64
Figure E.8-9: Map of Wet Season Scoring for the Mesohaline Zone VEC. 65
Figure E.8-10: Map of Wet Season Scoring for the Polyhaline Zone VEC. 66

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TRANSMITTAL LETTER FOR RECOVER SYSTEM-WIDE EVALUATION OF LOXAHATCHEE RIVER WATERSHED RESTORATION PROJECT (LRWRP)

REstoration COordination and VERification (RECOVER) Evaluation Team, Regional Evaluation Report

Date: August 10, 2018

To: Project Managers and Planning Technical Leads
Loxahatchee River Watershed Restoration Project
Comprehensive Everglades Restoration Plan

Dear Project Team Managers and Planning Technical Leads,

RECOVER has completed its regional evaluation of the Loxahatchee River Watershed Restoration Project (LRWRP) alternative plans and our final report is attached.

RECOVER's evaluation of project alternatives fulfills the following requirements as required by the 2003 CERP Programmatic Regulations 33 CFR Part 385.26(c):

1. Support project teams to achieve consistency with the Comprehensive Everglades Restoration Plan's (CERP) goals and objectives;
2. Document the performance of the project alternative plans using RECOVER approved system-wide performance measures, project performance measures (when appropriate), and best professional judgment. RECOVER determines the ability of each alternative plan to meet the targets established for each performance measure and describes the resulting effects upon the natural system. When appropriate, RECOVER evaluations include a qualitative analysis on how the project fulfills CERP goals and objectives;
3. Suggest improvements to the project, which if pursued could improve project performance or enhance benefits to the natural system;
4. Provide insight, if possible, and alert the project teams of any inconsistent modeling assumptions for the project as originally modeled in the CERP.

Recommendations discussed within the RECOVER regional evaluation report generally fall into one of three categories:

1. Recommendations that can easily be incorporated into the plan formulation process;
2. Recommendations that are more conceptual in nature, which the Project Team may select to incorporate into preliminary designs to improve project performance; and
3. Recommendations that are crucial to the project, but cannot be addressed prior to the TSP Milestone meeting.

Concerning the latter category, RECOVER provided its regional evaluation to satisfy the need for timely reporting, while bringing forward as much science as possible. As a result, this report may not constitute

the entirety of RECOVER's review as specified in the Programmatic Regulations. Therefore, RECOVER may provide additional information supporting and refining the original regional evaluation, with the expectation that those additional evaluation comments be considered by the project team.

Best Regards,

RECOVER Executive Committee

(Patti Gorman, Donna George, Fred Sklar, Agnes McLean, Gretchen Ehlinger, Laura Brandt)

E INTRODUCTION

E.1 Background and Purpose

This report documents the REstoration COordination and VERification (RECOVER) team system-wide/regional evaluation of the Loxahatchee River Watershed Restoration Project (LRWRP) required by the Comprehensive Everglades Restoration Plan (CERP) programmatic regulations 33 Code of Federal Regulations 385.20(e)(2). RECOVER is an independent (from the project delivery team [PDT]), interagency, and interdisciplinary team made-up of scientists charged with helping PDTs ensure their project's plans, designs, and performance are fully linked to the goals and objectives of CERP. The purpose of system-wide evaluations are to: (1) inform the PDT of the compatibility of proposed project alternative plans with regional CERP restoration goals and performance expectations; (2) determine the performance of each alternative plan toward meeting system-wide goals and objectives through the use of system-wide performance measures, project performance measures, and best professional judgment; (3) identify improvements for project performance that would improve system-wide performance; and (4) provide decision-makers required information regarding system-wide performance expectations of specific projects. This report documents the performance of the project alternatives in accordance with these four (4) tenets and, also, highlights the ability of each alternative to meet RECOVER system-wide/regional performance targets and documents expected effects on the natural system.

E.2 LRWRP Goals and Objectives

The purpose of CERP is to modify structural and operational components of the Central and Southern Florida (C&SF) Project to achieve restoration of the Everglades and the south Florida ecosystem, while providing for other water-related needs such as urban and agricultural water supply and flood protection. The sixty-eight (68) components of CERP will work together to benefit the ecological structure and function of the south Florida ecosystem by improving and/or restoring the proper quantity, quality, timing, and distribution of water in the natural system.

Table E-1: CERP Goals and Objectives

Goal & Objective Ids.	Goal and Objective Description
1	**Enhance ecological values.**
A	Increase the total spatial extent of natural areas.
B	Improve habitat and functional quality.
C	Improve native plant and animal species diversity.
2	**Enhance economic values and social well-being.**
A	Increase availability of fresh water (agricultural/municipal and industrial).
B	Reduce flood damages (agricultural/urban).
C	Provide recreational opportunities.
D	Protect cultural and archaeological resources and values.

LRWRP is composed of increments of project components that were identified in CERP. The term "increment" is used to underscore that this study will formulate portions (scales) of individual components of CERP. It is envisioned that later studies will investigate additional scales of components of CERP to

expand upon this initial "increment" to achieve the level of restoration envisioned for CERP. Portions of three (3) of the 68 components of CERP are being evaluated within LRWRP.

Table E- 2: LRWRP Goals and Objectives

CERP Objective	LRWRP Objective
Enhance Ecological Values - Increase the total spatial extent of natural areas	Objective 3: Increase natural area extent of wetlands.
Enhance Ecological Values - Improve habitat and functional quality	Objective 1: Restore wet and dry season flows of water to the National Wild and Scenic Northwest Fork of the Loxahatchee River and the river floodplain. Objective 2: Restore oysters, seagrass and other estuarine communities in the Loxahatchee River Estuary. Objective 4: Restore connections between Corbett WMA, Pal-Mar/Cypress Creek basin, Loxahatchee Slough, Grass Waters Preserve and Loxahatchee River to improve hydrology, sheetflow, hydroperiods, natural storage, and vegetation communities.
Enhance Ecological Values - Improve native plant and animal species abundance and diversity	Objective 5: Restore native plant and animal species abundance and diversity in Loxahatchee River watershed natural areas, river, and estuary.
Enhance Economic Values and Social Well Being - Increase availability of fresh water (agricultural/municipal & industrial)	No corresponding objective. Potential incidental benefit to increase availability of water supply.
Enhance Economic Values and Social Well Being - Reduce flood damages (agricultural/urban)	No corresponding objective. Potential incidental benefit.
Enhance Economic Values and Social Well Being - Provide recreational and navigation opportunities	No corresponding objective, but project will provide recreational opportunities consistent with ecosystem restoration.
Enhance Economic Values and Social Well Being - Protect cultural and archeological resources and values	No corresponding objective, but project will protect cultural and archeological resources and values.

LRWRP goals and objectives are consistent with those of CERP, as described in Table E-1 and Table E- 2. LRWRP focuses primarily on the restoration of water connectivity which will lead to: (1) the achievement of natural community restoration, resulting in (2) the increase in species abundance and diversity. LRWRP restoration fulfills CERP's goal to enhance ecological values while concurrently improving the recreational opportunity and experience associated with the "National Wild and Scenic" Northwest Fork of the Loxahatchee River and Estuary, partially satisfying CERP's second goal to "enhance economic values and social well-being." Improvements to connectivity, flow, and species composition should positively influence the health of the system as well.

E.2.1 Model Assumptions and Project Alternatives

As part of the RECOVER regional evaluation, the "future without project" (FWO) alternative was compared to four "with project" alternatives (ALTs) aimed at restoring and sustaining the overall quantity, quality

timing, and distribution of freshwater to the federally designated "National Wild and Scenic River" Northwest Fork of the Loxahatchee River (NWFLR) for current and future generations and restoring, sustaining, and reconnecting the area's wetlands and watersheds that form the historic headwaters for the river as proposed in the following CERP components:

- Pal Mar and J.W. Corbett WMA Hydropattern Restoration (OPE)
- WPAs/L-8 Basin (K)
- WPAs/L-8 Basin (GGG)

E.2.1.1 Model Assumptions Regarding the FWO

- Project Location: The active model boundary covers the entire LRWRP area, which stretches from Lake Okeechobee on the west to the Intracoastal Waterway on the east, from the C-44 canal on the north to the C-51 and the L-10/L-12 canals on the south. The 41-year period of simulation is from 1965 through 2005.
- Regional System: The Lower East Coast sub-Region North Palm Beach model (LECsR-NP) does not simulate regional water management and relies on the Regional 2x2 South Florida Water Management Model (SFWMM) for internal boundary conditions for the L-8, C-51 and C-44 canal stages, as well as flows from the regional system to the M-Canal to supply the City of West Palm Beach. Regional system flows through the M-Canal Control 2 pump station supplied by the SFWMM are reduced by seven (7) percent to account for seepage losses between Control 2 and Control 3 on the M-Canal because the model places this water directly into the M-Canal in the Grassy Water Preserve (GWP).
- L-8 Basin and/or C-51 Storage: Runoff available in the L-8 Basin is calculated for the West Corbett, Dupuis, Cypress Groves, and adjacent agricultural areas including the northwestern portion of the EAA from the ET-Recharge program. Additional inflow to the basin occurs, utilizing the reinjection drainflow (RDF) package, for the drainage canals located parallel to the L-8 Canal on the western and southern side of Dupuis and Corbett areas. Additional water is available as seepage into the L-8 Canal itself which is simulated as a river and obtains its daily stage from the SFWMM run. Some of the runoff is lost from the basin to provide irrigation to the eastern portion of the EAA and the agricultural areas in the Indian Trail Improvement District (ITID) area.
    - L-8 FEB: Simulation of stages within the L-8 FEB are obtained from the Restoration Strategies DMSTA 2012 Project modeling. Water levels within the facility can vary from approximately 13 feet NGVD to -40 feet NGVD.
    - C-51 Reservoir Phase 1: The C-51 Reservoir Phase 1 is simulated as an active, fully mined site.
    - C-51 Reservoir Phase II: The C-51 Reservoir Phase II storage is simulated as a partially mined site.
- M-Canal Conveyance
    - Control 2 Pump Station (WPB #2): The new 300 cfs pump station is completed but is restricted to a maximum rate of 225 cfs because of canal limitations. Flows through Control 2 are derived from the SFWMM run and simulated in the model using the diversion package.

- Grassy Waters Preserve (WPB Catchment Area) Deliveries: The M-Canal is maintained at a maximum stage of 18.9 feet NGVD. Regional system inflows are not provided to the M-Canal when stages are above 18.9 feet NGVD, in GWP, using the diversion package. Water supply for the City of West Palm Beach out of the M-Canal is simulated using the well package with withdrawal points along the M-Canal within GWP.
- Loxahatchee Slough Area:
    - Northlake Bridge: If stages in northern GWP are greater than 19.2 feet NGVD, water is diverted north across Northlake Blvd. using the diversion package.
    - Beeline Hwy Bridge: The Beeline Highway Bridge is indirectly modeled by allowing runoff west of the bridge to pass into the southern portion of the slough without restrictions.
- C-18W Storage:
    - East Corbett Weir: The weir is simulated at an elevation of 21.5 feet NGVD. The Corbett Weir is a sheet pile weir located in a heavily vegetated area which restricts flow. For simplification purposes, maximum flow over the weir is restricted to 50 cfs. It is simulated with the RDF package and discharges into the C-18 canal upstream of the C-18 weir. Water flows over the weir, across a road and into a ditch which connects the extreme western end of the C-18W canal.
    - Vavrus/Avenir: The Vavrus/Avenir property is assumed to be developed based upon existing plans. It is simulated as five distinct basins. The northern basin is a wetland restoration area with a control elevation of 20.5 feet NGVD and the existing agricultural ditches are filled. This northern wetland basin discharges to the C-18 canal upstream of the weir. The northeast corner of the property is a separate wetland restoration basin and is smaller than the northern wetland basin with a control elevation of 18.5 feet NGVD. It discharges east underneath the Beeline Highway into the Lox Slough and the southern C-18 canal leg. The southwest basin, Basin 3, is a wetland urban mix with a general control elevation of 20.0 feet NGVD. This basin discharges into Basin 1. Basin 1 is located in the south east corner of the property and is urban with a control elevation of 18.0 feet NGVD. This basin discharges into the smaller northeastern wetland basin. Basin 2 is an urban basin located in the middle of the property immediately south of the main wetland restoration basin. It has a control elevation of 18.5 feet NGVD and discharges northward into the main wetland restoration area.
    - NPBC Airport: Runoff from the airport drains east towards the southern leg of the C-18 Canal using the diversion package.
- C-18 Weir, G-92, and Lainhart Dam:
    - C-18 Weir: Flows over the C-18 weir are governed by the weir equation at steps of approximately 0.2 feet intervals using the RDF package. Flows into the west leg of the C-18 canal occur as runoff or base flow from eastern Corbett, Hungryland, Pratt and Whitney, Mecca and Avenir using a combination of the RDF and diversion packages.
    - C-18 Canal operations: The C-18 canal operations are simulated as follows: S-46 discharges in excess of 2000 cfs, depending upon slough water levels and runoff volumes when C-18 water levels exceed 14.9 feet NGVD. Flows through G-92 to the Loxahatchee

River are simulated using the RDF package and are head dependent. In general, up to approximately 30 cfs passes when the C-18 canal stage is above 12.5 feet. Up to approximately 60 cfs passes when the C-18 canal stage is above 13.5 feet. When it rises to above 14.0 feet, approximately 90 cfs occurs. Once it exceeds 14.5 feet, a volume up to 200 cfs is allowed to pass over the G-92 structure. Reverse flow is uncommon and is not simulated.

- South Indian River Water Control District (SIRWCD) and Jupiter Farms: Jupiter Farms is simulated as distinct basins. The north-western most portion is simulated using the RDF package at 15.5 feet. The western basin and central basins are simulated using the RDF package with controls of 15.0, 14.5 feet respectively. The eastern portion of Canal 2 and Section 18 are simulated using the RDF package at 13.0 feet. The basin, which is their C-14 canal and feeder canals receives the runoff and base flows from the other three basins and discharges over Lainhart Dam using the drain package at an elevation of approximately 10.7 feet NGVD. The basin is located east of the C-18 Canal and discharges downstream of the S-46 structure using the drain package with control elevation of 14.0 feet. Runoff from the basin, using the ET-recharge program is directly put into the basin at the RDF cells using the diversion package.
- Loxahatchee Tributaries (Kitching, Wilson and the North Fork): Flows into Kitching Creek occur as runoff from the northern urban and agricultural operations using the diversion package. Kitching Creek proper is simulated with the drain package in the non-tidal reaches and with the river package for the tidal areas. Wilson Creek and the North Fork are also simulated using a combination of the river, drain and general head boundaries.
- Southern Martin County Properties:
    - Hobe St. Lucie Conservancy District (HSLCD): HSLCD is simulated using the drain package The: Unit 1 South Fork Structure is outside the area of concern, Unit 2 Cypress Creek structure is simulated at 2.0 ft. NGVD and Unit 3 Hobe Grove Ditch Structure at 11.0 ft. NGVD. Individual canal and farm operations within this area are discussed in the individual project descriptions.
    - Cypress Creek Canal: Cypress Creek Canal upstream of the dilapidated control structure is maintained at an elevation of 2.0 feet NGVD from the structure located just west of the Turnpike westward to the Culpepper property using the drain package for the canal itself. Runoff from the urban basins, the western Grove, Pal Mar, Unit 2, Nine Gems, Thomas Farms and the Cypress Creek natural area are simulated using the diversion package with flows determined from the ET-Recharge program.
    - Nine Gems (Pal Mar East) Properties: The entire Pal Mar property including the primary southern canal and the laterals are all controlled at 16.0 feet NGVD and simulated as a drain. Runoff from the basin is calculated using the ET-Recharge program and introduced back into the model using the diversion package.
    - Pal Mar West of Pratt Whitney Road: Runoff from the Pal Mar area, calculated from the ET-Recharge program are simulated using the diversion package and is assumed to discharge into the Cypress Creek Canal in the general area of the twin 84 inch culverts and other culverts in the area. The Pine Glades area east of Pratt Whitney Road also discharges to the Cypress Creek Canal using the diversion package and also has a seepage barrier simulated along the southeastern portion.

- Thomas Farms (TF): Thomas Farms drains in two directions the northern area is simulated with drains at a control elevation of 12.0 feet NGVD and is considered part of HSLCD Unit 2. The southern area is controlled at 16.0 feet NGVD and is also simulated as drains and discharges southeastward into the Nine Gems property. Runoff from the property is introduced back into the model using the diversion package.
- Hobe St. Lucie Conservancy District Unit 2: Unit 2 is simulated with a control elevation of 12.0 feet NGVD using the drain package. Runoff from the property drains directly into the Cypress Creek canal using the diversion package.
- Gulfstream West Property: Gulfstream West is controlled at an elevation of 8.0 feet NGVD using the drain package. Runoff drains directly into the Cypress Creek Canal via the diversion package.
- Moonshine Creek and Eastern Gulfstream Property: Hobe Grove Ditch structure is controlled at 2.0 feet NGVD from the Eastern Gulfstream property to where it intersects the Loxahatchee River proper. The Eastern Gulfstream property is simulated using the drain package with elevation ranging from 12 NGVD for the perimeter canal to 6.0 feet NGVD in the agricultural areas. Runoff, using the ET-Recharge program is discharged to the southern end of the Unit 3 canal which then discharges directly into the Hobe-Grove Ditch.
- Culpepper Property: The Culpepper culverts are simulated as follows. Because of the size of the model grid the twin 84 inch culverts and WCS-2 are simulated at 17.6 feet NGVD. WCS-3 is simulated separately but also at 17.6 feet NGVD. The Jupiter grade culvert is also simulated in the model at 18.5 feet NGVD.
- Cypress Creek and Shiloh Farms Property: Small culverts underneath Gulfstream Road are not directly simulated in the model. The model assumes overland flow across the road. Improvements to this area are not included in the existing conditions.
- Ranch Colony and other Development Communities: The control elevations for these small parcels are simulated in the model using the drain package at the elevations specified.

- Indian Trail Improvement District (ITID) M-1 Basins:
  - Maximum discharge from ITID is limited to 750 cfs for the upper and lower basins using the RDF package. Flow in the south portion of ITID, south of the lower basin, is simulated using the drain package.
  - ITID flows head south to the C-51 canal.
  - Control elevations in the upper and lower basins of ITID are controlled using the RDF package at the elevations specified for each basin.
- Other Related Project Structures (outside LECsR-NP model boundary):
  - Stages at S-155 and S-155A are boundary conditions along the southern edge of the model. Stages for these canals are obtained from the SFWMM run.
  - STA-1E and STA-1W are outside the active model domain and are not simulated.
- Pumping and Water Restriction Areas:

- Public Water Supply (PWS) wellfield withdrawals from the surficial aquifer system (SAS) are simulated using the permitted allocations. In the case of West Palm Beach, the city's surface water withdrawals are represented in the model as SAS withdrawals from the M-Canal within the Grassy Waters area.
- Coastal well triggers are used to simulate water shortages when the potential for salt water intrusion exists into localized areas. Due to recent modifications made by the utilities several now partially rely upon the Floridan aquifer to meet their demands. This results a significant reduction in the threat of localized salt water intrusion in a number of coastal areas of the model domain and was implemented through the South Florida Water Management District (SFWMD) permitting process. However, the Palm Beach County area still undergoes water shortage restrictions when the SFWMD regional system is threatened due to low Lake Okeechobee stages. Lake Okeechobee lake triggers are obtained from the SFWMM model and occurred in Nov. 1972; Nov. 1976; Nov. 1977; Nov. & Dec. 1981; Jan. & Feb. 1982; Dec. 1989; Feb. 1990; Dec. 1990; Jan. 1991; Dec. 2000; and Jan. and Feb. 2001. When a water shortage is triggered it generally stays into effect through the dry season.

E.2.1.2 Flow Ways

Flow ways (FWs) are defined as general locations within the LRWRP project area based on existing natural areas, topography, and associated canals. FWs are generally separated by developed lands. Within the LRWRP there are three defined FWs, simply referred to as FW1, FW2, and FW3 (Figure E-1).

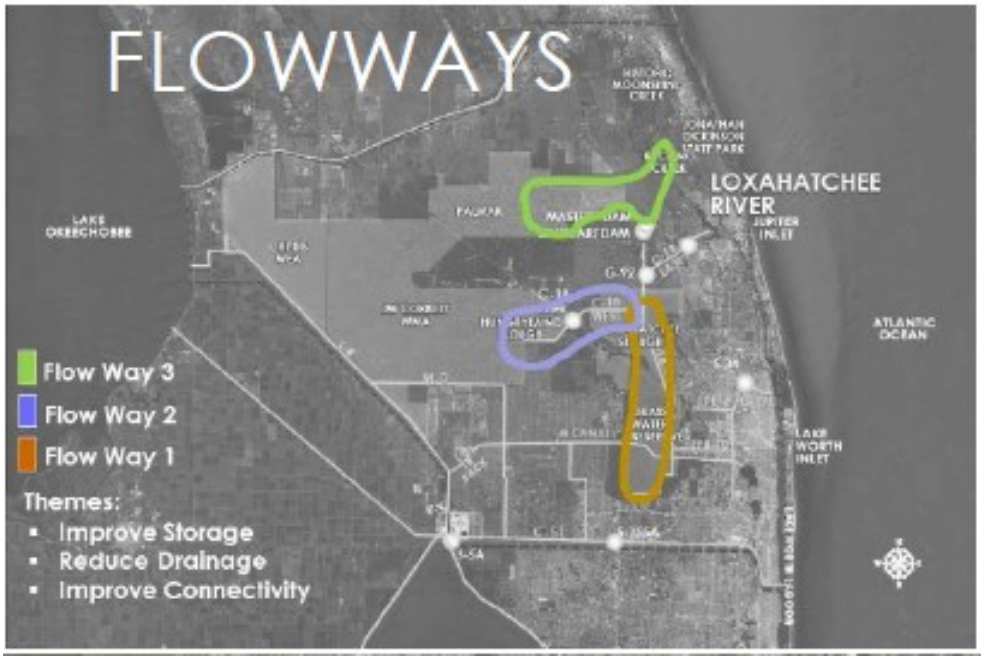


Figure E-1: Orientation of Three Flow Ways within the Loxahatchee Watershed.

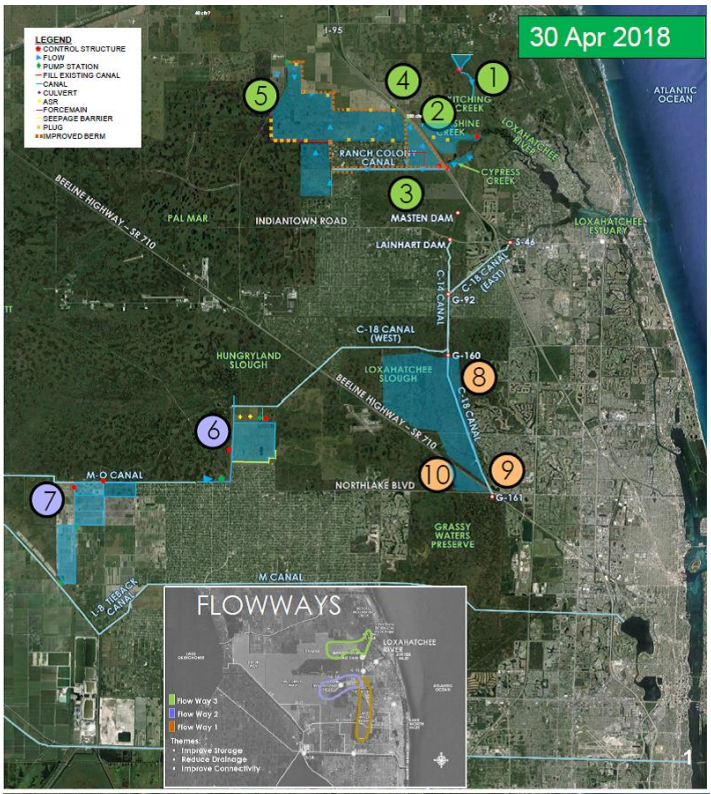
E.2.1.3 Project Alternatives

The PDT initially developed a list of 98 management measures for LRWRP which included: spreader canals, pump stations, conveyance canals, weirs, backfill/plugging of canals, removal of levees and berms, bridges and culverts, storage features, seepage barriers, operational changes (and other non-structural solutions), vegetation management measures, and adaptation planning measures. These 98 measures were initially screened to 85. The remaining measures were then combined into components and screened down to 21 components. These 21 components were further combined into "options" based on their location (flow way). Each option only exists in one FW (Figure E-1). FW1 had 7 options. FW2 had 7 options and FW3 had 6 options. The options under each FW underwent additional screening.

To achieve restoration flows to the NWFLR, contributions are needed from all three FWs. Initial alternatives were generated by combining one option from each FW, generating 8 alternatives. Two alternatives were proposed by local governments. Three alternatives were developed to improve initial alternatives and two alternatives were added to address questions about specific structures. In total, 15 alternatives made up the initial array of alternatives. In March 2016, the PDT implemented a scoring method for the 15 alternatives in the initial array. Six (6) alternatives were screened out based on scoring leaving nine (9) alternatives. The remaining nine (9) alternatives were then compared to one another for similarity. Four (4) alternatives were screened out due to their similarity with other remaining alternatives (the highest similar alternative was retained). The five (5) remaining alternatives were reduced to four (4) for the final array of alternatives (Figure E-2 and Figure E-3) with the elimination of Alternative 12 during the Alternatives Milestone Meeting.

ALTERNATIVE 2

1. Kitching Creek (Hydration) Spreader canal; weir/plug (Jenkins Ditch)
2. Moonshine Creek (MC) & Gulfstream East (GE) (Restoration): Connect HSLCD ditch to MC; clear MC vegetation; weir in Hobe Grove Ditch; regrade adjacent area to historic topography
3. Cypress Creek Canal (CCC) (Reduce Over-drainage): Replace CCC weir to raise control elevation, raise berm at Ranch Colony; automate twin 84" culverts;
4. Gulfstream West (Restoration & Reduce over-drainage): Partial backfill & relocate southern end of HSLCD canal; small pump, construct flow through marsh to attenuate flows
5. Palmar East (Restoration & Connectivity) Plug ditches; remove pipes; improve northern berm; construct western berm; improve eastern berm; pumps at Thomas Farm to redirect drainage to GW flow- through marsh via north Nine Gems canal
6. C-18W Reservoir (7,200 ac/ft & 2 ASR wells): Above-ground reservoir; inflow pump; discharge structure; seepage control; M-O Canal connector and pump
7. L-8 Basin Shallow Storage (4,300 ac/ft; includes pumps & channels)
8. G-160 Structure (Reduce Over-drainage): improve hydroperiod in Loxahatchee Slough
9. G-161 Structure (Connectivity): GWP water to Loxahatchee Slough
10. GWP Triangle (Connectivity)



ALTERNATIVE 5

1. Kitching Creek (Hydration): Spreader canal; weir/plug (Jenkins Ditch)
2. Moonshine Creek (MC) & Gulfstream East (GE) (Restoration): Connect HSLCD ditch to MC; clear MC vegetation; weir in Hobe Grove Ditch; regrade adjacent area to historic topography
3. Cypress Creek Canal (CCC) (Reduce Over-drainage): Replace CCC weir to raise control elevation; raise berm at Ranch Colony; automate twin 84" culverts;
4. Gulfstream West (Restoration & Reduce Over-drainage): Partial backfill & relocate southern end of HSLCD canal; small pump; construct flow through marsh to attenuate flow
5. Palmar East (Restoration & Connectivity) Plug ditches; remove pipes; improve northern berm; construct western berm; improve eastern berm; pumps at Thomas Farm; redirect drainage to GW flow-through marsh via north Nine Gems canal
6. C-18W Reservoir (9,500 ac/ft & 4 ASR Wells): Above-ground reservoir; inflow pump; discharge structure; seepage control; M-O Canal Connector and pump
7. G-160 Structure (Reduce Over-drainage): Improve hydroperiod in Loxahatchee Slough
8. G-161 Structure (Connectivity): GWP water to Loxahatchee Slough
9. GWP Triangle (Connectivity)
10. M-1 Pump Station (Conveyance): Deliver Lower M-1 Basin water to M-Canal, GWP, and G-161

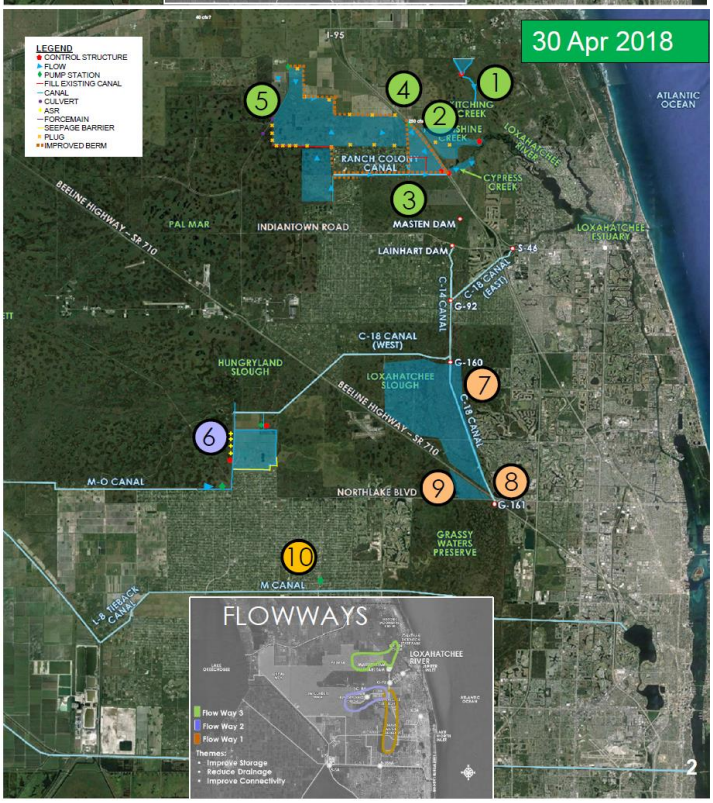
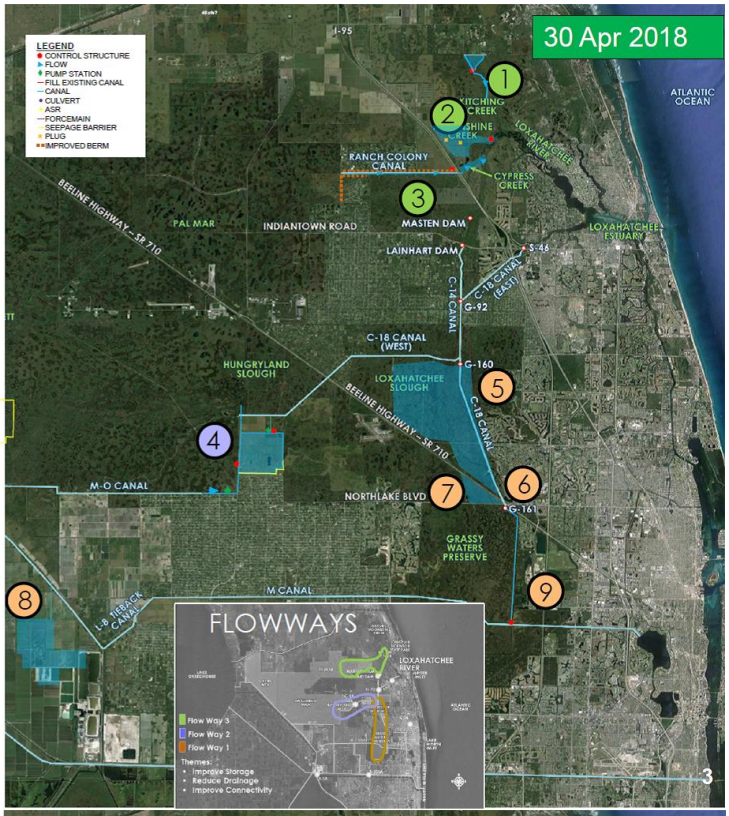


Figure E-2: LRWRP Alternatives 2 and 5.

ALTERNATIVE 10

1. Kitching Creek (Hydration): Spreader canal; weir/plug (Jenkins Ditch)
2. Moonshine Creek (MC) & Gulfstream East (GE) (Restoration): Connect HSLCD ditch to MC; clear MC vegetation; weir in Hobe Grove Ditch; regrade adjacent area to historic topography
3. Cypress Creek Canal (CCC) (Reduce Over-drainage): Replace CCC weir; raise berm at Ranch Colony; automate twin 84" Culverts
4. C-18W Reservoir (7,200 ac/ft): Above-ground reservoir; inflow pump; discharge structure; seepage control; M-O Canal Connector and pump
5. G-160 Structure (Reduce Over-drainage): improve hydroperiod in Loxahatchee Slough
6. G-161 Structure (Connectivity): GWP water to Loxahatchee Slough
7. GWP Triangle (Connectivity)
8. C-51 Deep Reservoir (Storage): 44,000 ac/ft; includes pump & channels
9. Force Main (Conveyance): Pump and pipeline through Grassy Waters Preserve to connect M-Canal to G-161



ALTERNATIVE 13

1. Kitching Creek (Hydration): Spreader canal; weir/plug (Jenkins Ditch)
2. Moonshine Creek (MC) & Gulfstream East (GE) (Restoration): Connect HSLCD ditch to MC; clear MC vegetation; weir in Hobe Grove Ditch; regrade adjacent area to historic topography
3. Cypress Creek Canal (CCC) (Reduce Over-drainage): Replace CCC weir; raise berm at Ranch Colony; automate twin 84" culverts; pump and spreader swale; regrade CC southern forks
4. Gulfstream West (Restoration & Reduce Over-drainage): Partial backfill & relocate southern end of HSLCD canal; small pump; construct flow through marsh to attenuate flow
5. Palmar East (Restoration & Connectivity): Plug ditches; remove pipes; improve northern berm; construct western berm; improve eastern berm; pumps at Thomas Farm to redirect drainage to GW flow through marsh via north Nine Gems canal
6. Natural Storage C-18W (Basin Restoration): Restore natural topography; seepage barriers; culverts for Beeline Hwy; backfill interior canals south of C-18W Canal; pump station at Mecca; flow-paths through Mecca & Avenir; M-O Canal connector & pump
7. L-8 Basin Shallow Storage (6,500 ac/ft & 4 ASR wells); includes pumps & channels
8. G-160 Structure (Reduce Over-drainage): improve Hydroperiod in Loxahatchee Slough
9. G-161 Structure (Connectivity): GWP water to Loxahatchee Slough
10. GWP Triangle (Connectivity)

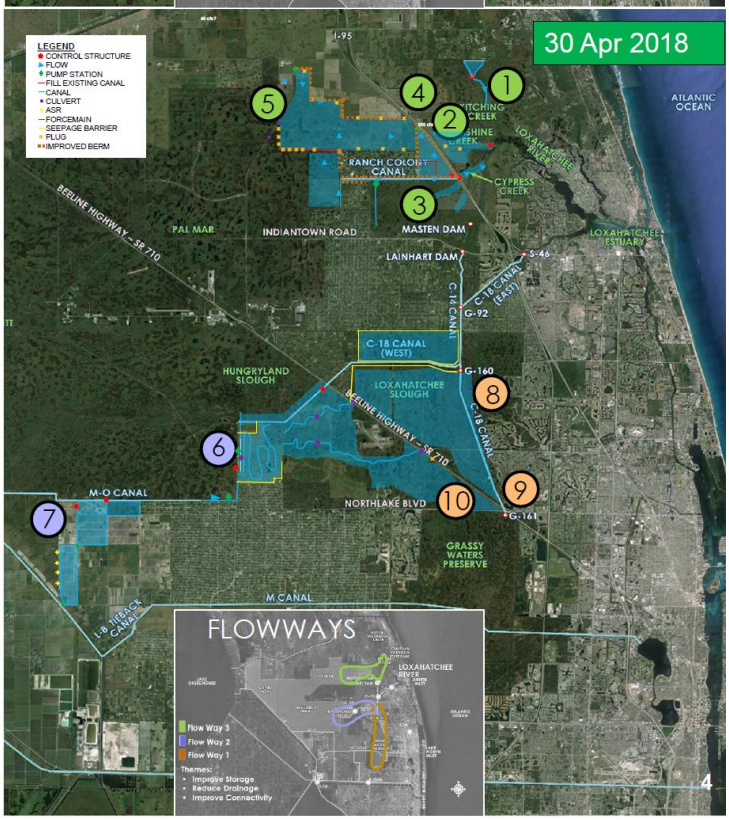


Figure E-3: LRWRP Alternatives 10 and 13.

E.2.1.4 Project Alternative 5R

Model results for the LRWRP ALTs were complete and posted for review on April 13, 2018. After the completion of the modeling results, the LRWRP PDT updated Alternative 5, in June 2018, to include a pump station and a spreader channel near Mack Dairy Road [from Alternative 13 (ALT13)] in FW3 after seeing the modeled benefits of these two features (Figure E-4). This change to Alternative 5 (ALT5) to Alternative 5R (ALT5R) did not result in additional modeling runs. Modeling data for FW3 in the new ALT5R exists in the modeling data for FW3 in ALT13 from modeling completed on April 13, 2018. ALT5 is no longer a consideration as a project alternative for LRWRP. With an addition of 1,383 wetland habitat units (performance measure #4 [PM4]), ALT5R replaced ALT5, and along with Alternative 2 (ALT2), Alternative 10 (ALT10), ALT13, and FWO make up the final array of alternatives for LRWRP as of this evaluation.

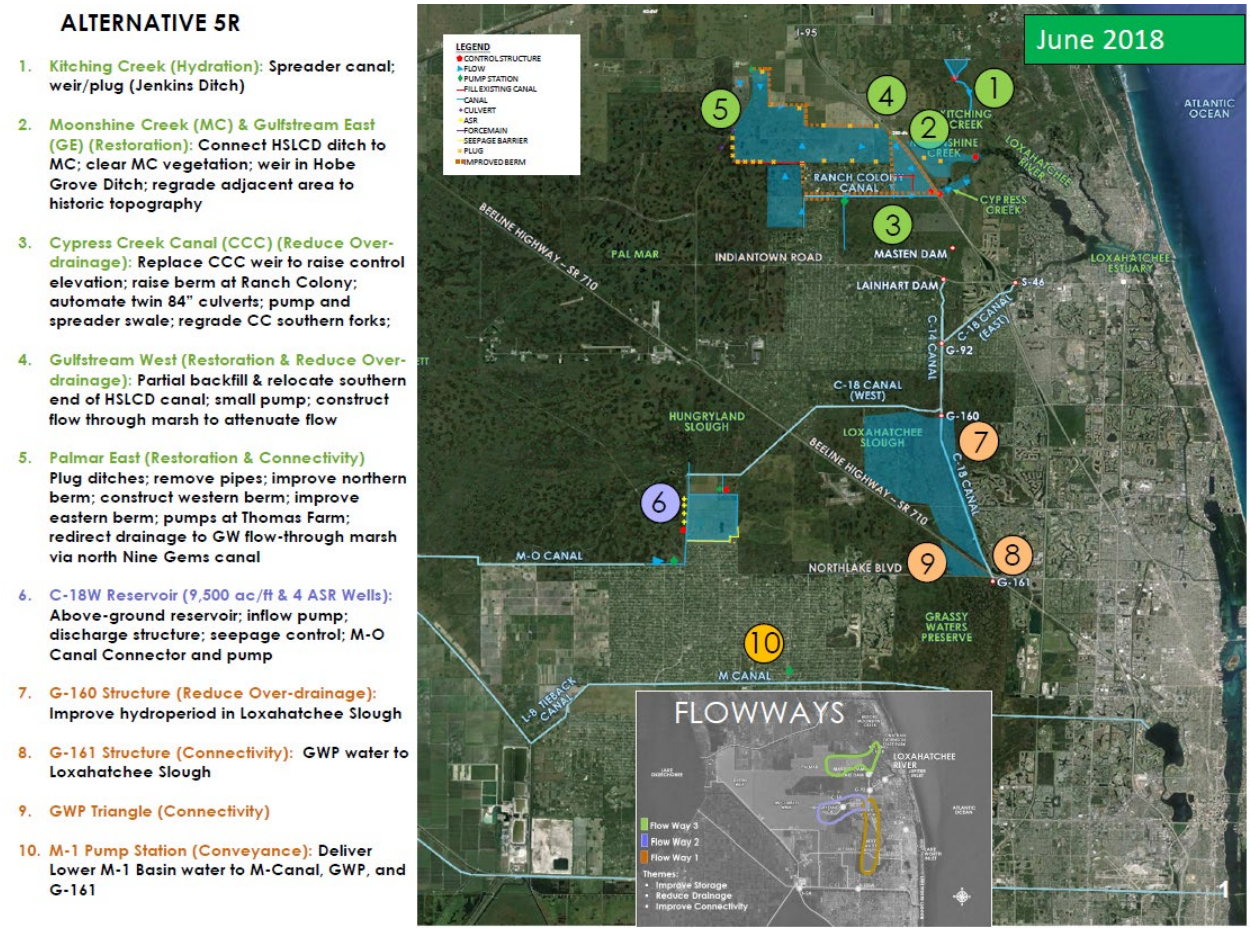


Figure E-4: LRWRP Alternative 5R (Revision of LRWRP ALT5).

E.2.2 Performance Measures

The performance measures (PM) used to define restoration targets and evaluation methodology were developed by the LRWRP PDT. As such, these are not RECOVER performance measures. However, each LRWRP performance measure, listed below, was reviewed by RECOVER as part of the LRWRP RECOVER Consistency Review. After evaluating each performance measure, RECOVER made comments and

suggestions to the LRWRP PDT resulting in final versions based on the most up-to-date science, knowledge, and methodology. The performance measures used in the evaluation of the LRWRP were:

- LRWRP Performance Measure 1 (PM1): Seasonal Flows to Manage Salinity and Floodplain Hydroperiod in the Northwest Fork of the Loxahatchee River
- LRWRP Performance Measure 4 (PM4): Hydrologic Regimes of Major Plant Communities in the Loxahatchee Watershed and Adjacent Wetlands
- LRWRP Performance Measure 9 (PM9): Hydrologic/Spatial Connectivity

PM1 evaluates restoration of the Northwest Fork of the Loxahatchee River and Estuary.

PM4 and PM9, in combination, evaluate the total Loxahatchee Watershed.

E.2.3 Uncertainty

Model uncertainty can be characterized in several forms (RECOVER 2002), but generally they fall into two categories: knowledge uncertainty or natural variability uncertainty. Knowledge uncertainty relates to errors in how a particular species or parameter will respond to various environmental and habitat conditions. Knowledge uncertainty can be measured using calibration statistics for the hydrologic models which can be propagated to the ecological models that use hydrologic output. The limits of a model's representation of actual factors or conditions can be described in model documentation reports. Natural variability relates to the temporal and spatial uncertainty with each input and output in the model and is further complicated by climate change nonstationarity. The significance of both types of model uncertainty is that it can pose a risk to identifying and implementing the best project plan to achieve restoration goals and objectives. Scenario analysis can be used to evaluate variations of an alternative which is more robust (perform better under a range of future conditions) to help minimize the risk associated with natural variability uncertainty. Adaptive management is another tool that can help reduce uncertainty associated with implementing the best alternative plan and operations to meet restoration performance goals.

E.2.3.1 Knowledge-based Uncertainty

Planning Uncertainty

The RECOVER regional evaluation made use of plan formulation assumptions for structure operations, structure maintenance, drainage, flow direction, flow rate, discharges, and land development within the LRWRP boundary (Section 1.3.1). If any of these assumptions are altered or not implemented, the results for each alternative could change.

Model Uncertainty

The hydrologic models used for evaluating the LRWRP is the Lower East Coast sub-Regional (LECsR) North Palm Beach (LECsR-NP) and the Regional 2x2 South Florida Water Management Model (SFWMM). The LECsR-NP is sub-regional version of the LECsR, which encompasses 5100 square miles over six sub-regions (North Palm Beach, South Palm Beach, Broward, Martin, North Miami-Dade and South Miami-Dade) and includes the Everglades Agricultural Area (EAA), Everglades National Park (ENP), and sections of Monroe and Collier counties. The LECsR model (including sub-regional models) is designed to assess differences

in groundwater flow, as well as, water supply and management. The model has a number of assessment module tools including: recharge, evapotranspiration (ET), river, drain, redirected flow, lake, operations, wetland, well, trigger, and reinjection drainflow. The current version of the LECsR also incorporates a weather module and ET-recharge and surface water management modules. The LECsR is compatible with and incorporates data from the SFWMM which assesses the relationship between water supply and demand in Palm Beach, Broward, Dade, and portions of seven other south Florida counties. The LECsR-NP model does have limitations and constraints which lead to model uncertainty. The "Model Calibration update of the Northern Palm Beach County Version of the Lower East Coast Subregional Model (LECsR-NP)" draft report states, "the model assumes constant fluid density, no transport, and no hydraulic routing. The model lacks canal-sizing capabilities and assumes canals have the capacity to route flows" (SFWMD 2017). There is limitation with the "Wetland Package (module)," which was designed to route overland flows but not to route open channel flows (SFWMD 2017). The LCEsR-NP is challenged to accurately simulate over land flow (including runoff and recharge) as it uses the year 2013 only to assess land use, which has changed over time due to urbanization and ongoing restoration projects (SFWMD 2017). The 2017 report also recommends review of rainfall and flow data, improvement of modeling software with less manual development, improvement to model packages for simulation of water delivery and canal routing process which will improve accuracy, and use multiple years of land use data during calibration.

Performance Measure and Ecological Planning Tool Uncertainty

The LRWRP regional evaluation is based on technical evaluation by RECOVER. This evaluation is performed using project-developed PMs (Appendix G) that have not gone through RECOVER scientific review and approval processes. RECOVER PMs typically describe performance measure uncertainty in the RECOVER documentation sheets for each PM. The project-developed PMs do not include information regarding uncertainty and how it might be addressed. Uncertainty exists with use/assessment associated with the ecological planning tool, PM1 Salinity Regression Tool, due to LECsR-NP errors and deficiencies in the model output that goes into the Salinity Regression Tool. The Salinity Regression Tool uses flow input to model salinity in the Northwest Fork of the Loxahatchee River (NWFLR). Model output from the LECsR-NP was in essence the same for tributary flow, which increased the uncertainty with output from the Salinity Regression Tool.

Knowledge Uncertainty

Performance measures and ecological planning tools are simplifications of the real relationships between hydrology and a particular ecological indicator of interest. Errors can result based on known and unknown responses of species and habitats (communities) to various environmental and other habitat conditions. This type of uncertainty is inherent with any ecosystem restoration project and is minimized by using the best available science to develop and interpret model results. In addition, uncertainty is addressed by proceeding with project implementation through an adaptive management approach that tests hypotheses about the best project design and operations to achieve desired results.

ASR Uncertainty

While a number of sources for uncertainty exist within LRWRP, the use of the small number of ASR wells at the scale envisioned for this project is not a significant source of uncertainty. The CERP ASR pilot projects and ASR Regional Study provided a substantial reduction in the degree of uncertainty regarding

regional implementation of the technology. The CERP ASR reports were reviewed in 2015 by the National Research Council of the National Academies' Committee on Independent Scientific Review of Everglades Restoration Progress (CISRERP). Although some additional follow-up studies were suggested, the CISRERP concluded that they could be accomplished through phased implementation and construction of ASR multi-well clusters (NRC 2015). RECOVER recommends the project pursue ecotoxicological testing of ASR technology to address the uncertainty associated with LRWRP's use of ASR that was identified as part of the CISRERP report on Everglades restoration progress.

E.2.3.2 Natural Variability-based Uncertainty

Climate Change Uncertainty

The LECsR-NP model uses a historic 41 year period of record (1965-2005) of rainfall and hydrology to simulate interaction of surface water/groundwater, evapotranspiration, and water management (movement of water through canals, structures, seepage, overland flow or estuarine flow) to estimate the flow, water depths and durations, and salinities in the estuaries. Project infrastructure (e.g., canals, water control structures) and operations are portrayed in abstraction that generally mimic the intent of the project features while not matching the exact mechanisms by which these operations would be achieved in the actual conditions. Climate change nonstationarity means that the past climatic conditions (41 year period of record for the hydrologic models) are not indicative of future climatic conditions. Uncertainty exists due to the inability to predict/forecast swings in rainfall from extreme storm events to extreme drought, rising temperatures, salt water intrusion, extent of sea level rise and the impacts resulting from these climate changes.

Sea Level Rise and Tidal Push

Historically, Jupiter Inlet went through periods of being open and closed (Hu 2002, Palm Beach County 2016). Sediment transport along with storm events most likely influenced the natural opening and closing, as well as migration of Jupiter Inlet. Dredging and stabilization of Jupiter Inlet increased hydraulic conveyance of the inlet and increased the tidal influence into the Loxahatchee River and Estuarine System (Hu 2002). Tidal influence is further exacerbated by an average sea level increase of 3.70 +/- 0.58 mm/year at Lake Worth Pier, approximately 23 miles south-southeast of Jupiter Inlet (Figure E-5) (NOAA). Ever rising sea levels increase the tidal reach further upstream of inlet associated rivers and tributaries resulting in salt water intrusion further upstream. Uncertainty exists in the predictability of salinity and tide regimes due to the unpredictability of future sea level rise.

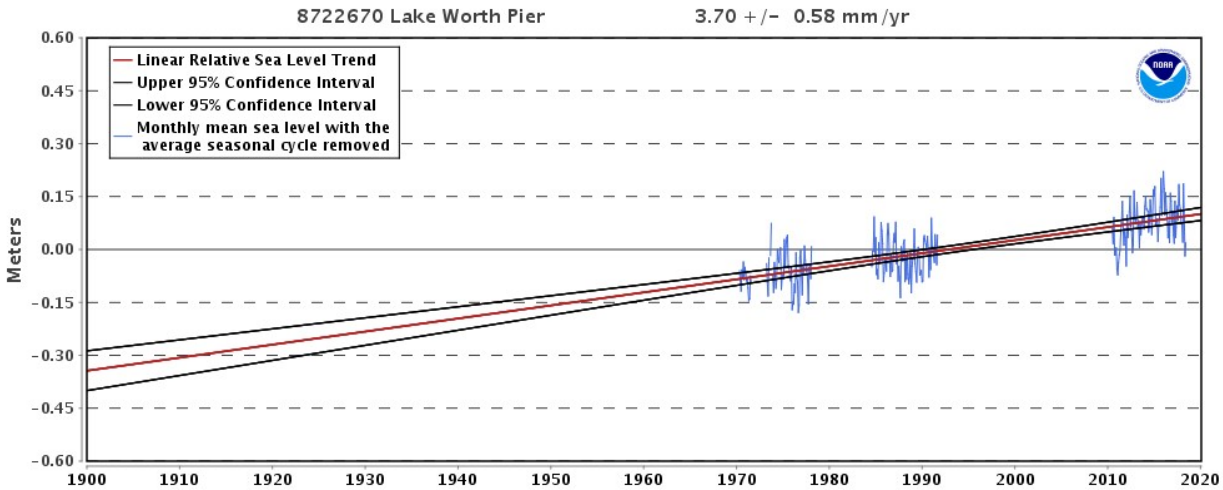


Figure E-5: Sea Level Trends at Lake Worth Pier since 1900 (NOAA).

Hurricane Frequency and Intensity

Hurricanes create an unpredictable setting when they near land. Hurricanes may affect the ecology within the boundary of the LRWRP via high shifting winds, storm surge, tidal push (saltwater intrusion), erosion, and high rainfall amounts. A study titled, "Effects of Two Hurricanes on *Syringodium filiforme*, Manatee Grass, Within the Loxahatchee River Estuary, Southeast Florida," revealed devastating effects of Hurricane Frances and Hurricane Jeanne in September 2004 to the ecology within the Loxahatchee River Estuary (Ridler et al. 2006). Effects of these two hurricanes included ecological damage (thinning) due to hurricane force winds in the estuary, increased rainfall (610 mm during September 2004 compared to 25 year average of 230 mm for September), increased discharge rates through the northwest and southwest forks of the Loxahatchee River (36.8 cubic meters per second monthly average for September 2004 [with a peak of 113.3 cubic meters per second] compared to 10.9 cubic meters per second monthly average for September over a 25 year period) (Ridler et al. 2006). This example shows the impacts hurricanes can have, regardless of strength. Increases in sea water temperatures associated with climate change may increase storm frequency and strength which adds a measure of unpredictability (uncertainty) regarding impacts of hurricanes on the LRWRP.

E.2.4 Evaluation Process and Organization

A RECOVER team (Table E.6- 1), consisting of members representing the RECOVER regions of Lake Okeechobee (LO), Northern Estuaries (NE), Greater Everglades (GE), and the Southern Coastal Systems (SCS), evaluated LRWRP ALTs using approved project PMs, best available scientific information, and best professional judgment. This evaluation was performed, utilizing the knowledge and expertise representative of the system as a whole, to help in understanding the regional hydrological and ecological performance of each alternative. This RECOVER system-wide (regional) evaluation report is organized by three impact areas associated with LRWRP: (1) Northwest Fork of the Loxahatchee River and Estuary, (2) Loxahatchee Watershed, and (3) Lake Okeechobee lake stage. Impacts to the RECOVER Module "Southern Coastal Systems," are not anticipated as a result of LRWRP. A summary of this RECOVER regional evaluation and recommendations are included in the executive summary, found in Annex E of the LRWRP Project Implementation Report/Environmental Impact Statement (PIR/EIS). Background information on

LRWRP goals, objectives, assumptions, and alternatives is included in this section. The following sections describe the evaluation process used to assess each impact area.

E.3 NORTHWEST FORK OF THE LOXAHATCHEE RIVER AND ESTUARY

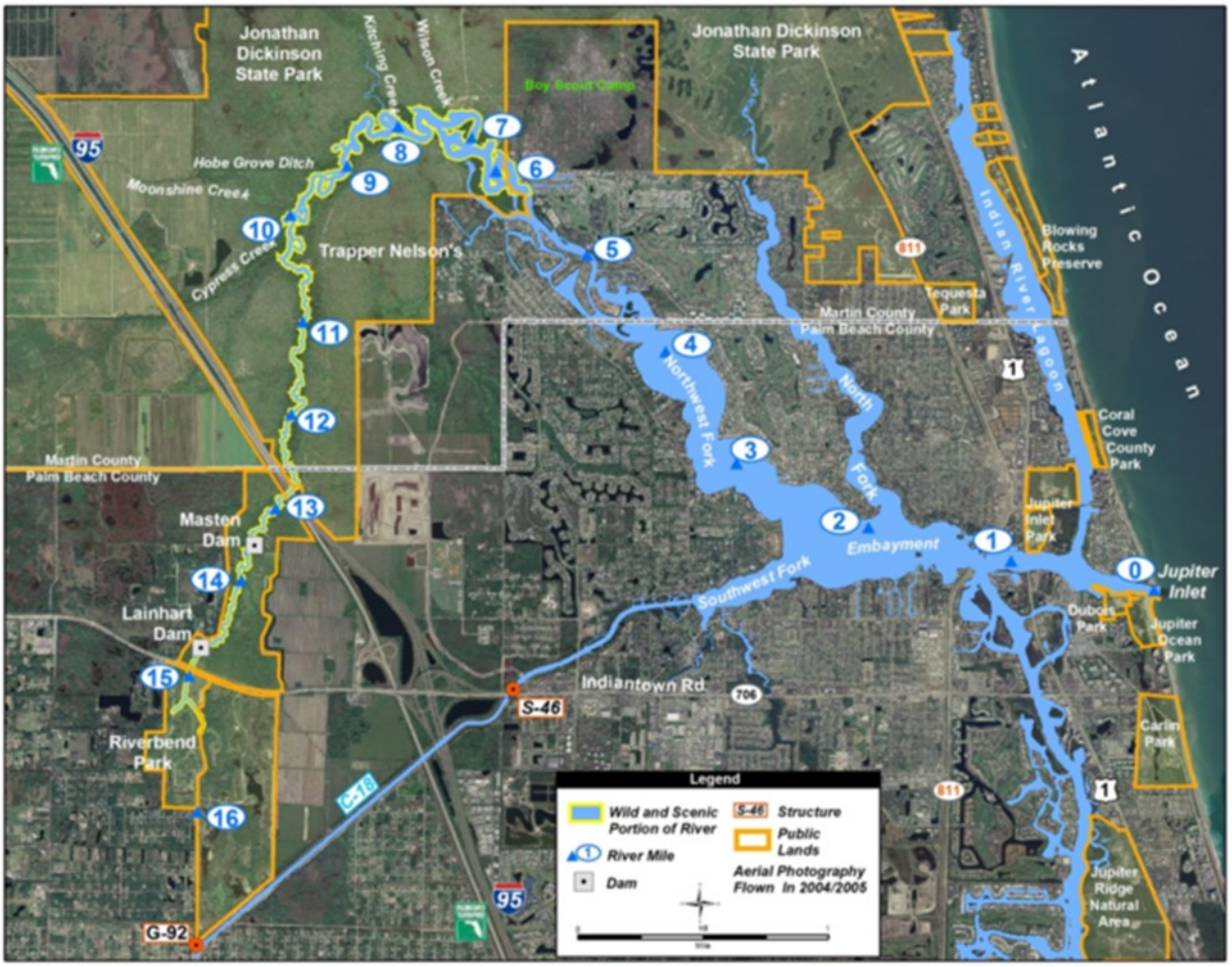


Figure E.2- 1: Map of the Loxahatchee River and Estuary.

E.3.1 Introduction

Designated in 1985 as a "National Wild and Scenic River," the NWFLR is one of only two rivers in Florida to have that distinction. The NWFLR is one of three forks, along with the north fork and southwest fork, which flows into a central embayment to form the Loxahatchee River and Estuary (Figure E.2- 1). Historically, the Loxahatchee River has drained the approximately 218 square mile Loxahatchee River Watershed, until the early to mid-1900s when water control was implemented to support land development, navigation, and agricultural practices (VanArman et al. 2005). This resulted in the creation of hydrologic units within and adjacent to the historic watershed resulting in the current drainage of approximately 240 square miles (SFWMD et al. 2010). In the 1930s, Lainhart (Figure E.2- 2) and Masten (Figure E.2- 2) dams were constructed which reduced freshwater flow to the NWFLR resulting in improved conditions for the freshwater floodplain surrounding the upper NWFLR. In 1948, Jupiter Inlet was

permanently opened and stabilized which increased tidal exchange allowing for salt water intrusion directly from the Atlantic Ocean to infiltrate farther upstream in the NWFLR. Prior to 1948, Jupiter Inlet had a history of naturally opening and closing over time, as well as, anthropogenic manipulation (Palm Beach County 2016) with the earliest documented opening occurring 1837. In 1958, the C-18 canal was constructed which drained the Loxahatchee Watershed. The implementation of the C-18 canal diverted the majority of freshwater flow into the central embayment via the Southwest Fork, effectively cutting off one of the major sources of water to the NFLWR in the Loxahatchee Slough. In 1975, the G-92 structure was constructed to redirect some flow back to the NWFLR. In 2018, the South Florida Water Management District (SFWMD) completed the "Lainhart and Masten Dams Maintenance Repair Project," which included seepage correction, erosion control, bank repair and stabilization, structural repairs, and portages corrections (SFWMD 2015). Today, half of the freshwater flow to the NWFLR comes via the Lainhart Dam. Other sources of freshwater to the NWFLR are groundwater seepage and other tributaries (Cypress Creek, Hobe Grove Ditch, and Kitching Creek) (Figure E.2- 1).

Figure E.2- 2: Lainhart Dam at 15 cfs (pre-2018).

Figure E.2- 3: Masten Dam during higher flows (pre-2018).

Due to the intrusion of salt water as a result of reduced freshwater flows and the creation of a direct source of tidal oceanic salt water, the ecology of the NWFLR has not only been subject to degradation but has resulted in ecological regime shifts further upstream from the Loxahatchee Estuary. To address these issues, the purposes of LRWRP include: (Goal 1) restore and sustain the overall quantity, quality, timing, and distribution of freshwaters to the federally designated "National Wild and Scenic" Northwest Fork of the Loxahatchee River for current and future generations, and (Goal 3) restore and sustain salinity conditions in the Loxahatchee River Estuary (Table E- 2).

E.3.2 Performance Measures and Evaluation Approach

To assess the effects of the LRWRP, model output from four (4) project alternatives is contrasted and compared against targets and two different "base" conditions: the Existing Condition Baseline (ECB) and the Future Without Project (FWO). The ECB (2014B) represents the present configuration and operation of the water management system. The FWO (2070FWO) simulates a future configuration of the water management system without LRWRP but with future, additional restoration, and structural and operational components described in Section **Error! Reference source not found.**.

The analysis for the NWFLR was completed using modeling data and results provided by the PDT for project-level evaluation PM1, "Seasonal Flows to Manage Salinity and Floodplain Hydroperiod in the Northwest Fork of the Loxahatchee River." PM1 was developed by the LRWRP PDT as an evaluation tool to assess the ability of project alternatives to achieve certain LRWRP objectives pertinent to the NWFLR by measuring wet and dry season flows to improve salinity and floodplain hydroperiods in the NWFLR (Objective 1 – Table E- 2). PM1 uses regression equations that link flows to salinities downstream of Lainhart Dam and into the various salinity zones throughout the NWFLR (Objective 2- Table E- 2). PM1 is based upon targets for seasonal flows and hydroperiods using a Valued Ecosystem Component (VEC) approach (USEPA 1987). VECs are species or communities that convey a complex message of ecological community composition and health in a simplified and useful manner (USEPA 1987). For LRWRP, the VECs are associated with characteristic salinity and hydrologic regimes at desired locations, with which project alternative scenarios are compared. There is some overlap in the VEC regimes, with their desired locations defined by river mile (RM) (Figure E.2- 1) in PM1:

1. Flood Plain Swamp and Hydric Hammock in the Freshwater **Riverine Flood Plain**: RM 16 to RM 9.5
2. Flood Plain Swamp in the **Tidal Flood Plain**: RM 9.5 to RM 8.0
3. Tape grass, ***Vallisneria*** *americana*: RM 10.5 to RM 6.5
4. Fish Larvae in the **Oligohaline Zone**: RM 10 to RM 5.5
5. Oysters in the **Mesohaline Zone**: RM 6.0 to RM 3.5
6. Seagrasses in the **Polyhaline Zone**: RM 4.0 to RM 0.0

A significant stressor for the VEC regimes is the alteration of salinity throughout the NWFLR. Species composition throughout the ecological communities associated with these VECs has shifted since the permanent opening and stabilization of Jupiter Inlet due to saltwater intrusion. Conceptually, altered hydrology in the form of reduced flows (stressor) coupled with altered salinity (ecological effect) and saltwater intrusion (ecological effect) have resulted in saltwater intrusion further upstream and a shift in the location/boundaries of salinity zones throughout the NWFLR. In order to restore the VEC regimes mentioned above, salinity targets for each VEC were developed. The salinity targets associated with each of these six (6) VECs are:

1. **Riverine Flood Plain**: 0 psu (practical salinity unit)
2. **Tidal Flood Plain**: < 2 psu
3. ***Vallisneria***: < 5 psu
4. **Oligohaline Zone**: 2 – 8 psu
5. **Mesohaline Zone**: 10 – 20 psu
6. **Polyhaline Zone**: > 20 psu

Despite some overlap in VECs, each are evaluated individually in this analysis.

E.3.3 Evaluation

All graphics utilized to evaluate the performance of LRWRP ALTs for restoration of the NWFLR contain the modeling results for ALT5 which was replaced in the final array of ALTs by ALT5R. The NWFLR lies in FW3 (Figure E-1). ALT5R and ALT13 have the exact suite of project features for FW3 (Figure E-3 and Figure E-4). For ALT5R, modeling data for FW1 and FW2 is the same as ALT5 and the same as ALT13 for FW3. Therefore, the modeling results for the tributaries of the NWFLR (Cypress Creek, Hobe Grove Ditch, and Kitching Creek) are the same for ALT5R and ALT13. Flow into the NWFLR via the Lainhart Dam for ALT5R is the same as ALT5, as the flow source is not in FW3.

E.3.3.1 Objective 1: Restore Wet and Dry Season Flows

Freshwater flow to the NWFLR from the Loxahatchee Watershed via the Loxahatchee Slough (Lainhart Dam) and tributaries (Cypress Creek, Hobe Grove Ditch, and Kitching Creek) is vital to the overall health and ecological maintenance of the NWFLR. The 2006 Restoration Plan for the Northwest Fork of the Loxahatchee River determined the restoration targets for flow during the wet season and dry season (SFWMD and FDEP). The wet season flow restoration target is to achieve flows greater than 110 cfs for a minimum of 120 days between August and November (SFWMD and DEP 2006). The dry season restoration flow restoration target is to have variable flows between 50 and 110 cfs, with a mean monthly flow of 69 cfs over Lainhart Dam, and an additional 30 cfs from downstream tributaries when needed (SFWMD and FDEP 2006). LRWRP alternatives were assessed on how often they achieved (% of years within the POR) the restoration targets during the wet season and dry season throughout the POR (1965-2005) (Table E.2- 1).

Table E.2- 1: Success of LRWRP Alternatives Achieving Flow Restoration Targets for the Wet Season and Dry Season to the NWFLR.

Flows	ECB	FWO	ALT2	ALT5R	ALT10	ALT13
Wet Season*	76%	78%	98%	98%	100%	98%
Dry Season**	65%	65%	87%	91%	95%	80%

*Wet Season (August – November): flows of greater than 110 cfs for a minimum of 120 days.
**Variable Dry Season Flow: flows between 50 and 110 cfs, with a mean monthly flow of 69 cfs over Lainhart Dam, and an additional 30 cfs from downstream tributaries when needed.

Compared to the FWO, all LRWRP ALTs greatly improved freshwater flow to the NWFLR (Table E.2- 1) via the Lainhart Dam. Regarding wet season freshwater flow, improvements ranged from 20% (ALT2, ALT5R, and ALT13) to 22% (ALT10). There was little separation among the ALTs, however, ALT10 did outperform all other ALTs by 2%. Disparity in alternative success is more evident in the assessment of dry season flows to the NWFLR. Improvement of dry season flows from the FWO ranged from 15% (ALT13) to 30% (ALT10), with ALT2 and ALT5R in the middle (22% and 26% improvement from FWO respectively).

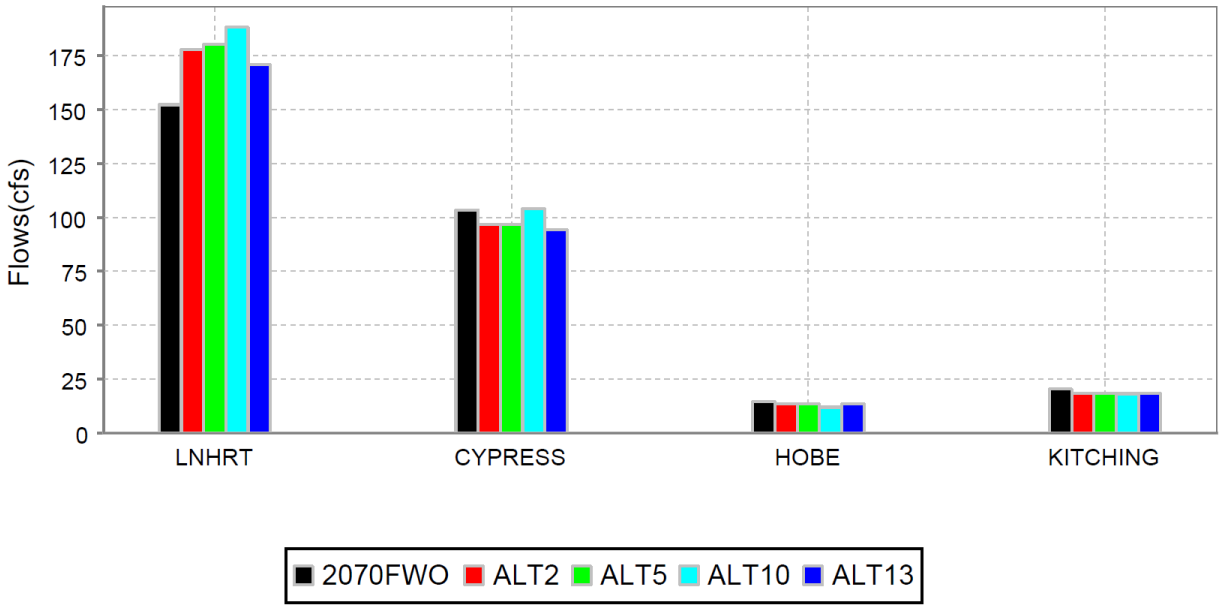


Figure E.2- 4: Contribution of Average Daily Tributary Flows to the NWFLR for the 41 POR (1965-2005).

Historically, surface water reaching the NWFLR entered via Lainhart Dam, Cypress Creek, Hobe Grove Ditch, and Kitching Creek (Figure E.2- 1). Approximately 50% of freshwater flow in the NWFLR arrived via Lainhart Dam with 32%, 5%, and 13% of freshwater flows entering via Cypress Creek, Hobe Grove Ditch, and Kitching Creek respectively. Estimations of flow to the NWFLR were made utilizing data from Figure E.2- 4.

Table E.2- 2: Average Daily Flow to the NWFLR (cfs) Regardless of Season.

Flow Source	FWO	ALT2	ALT5R	ALT10	ALT13
Lainhart Dam	150	177	180	188	171
Cypress Creek	102	98	96	103	96
Hobe Grove Ditch	13	12	12	10	12

Flow Source	FWO	ALT2	ALT5R	ALT10	ALT13
Kitching Creek	20	19	19	19	19
Total	285	306	307	320	298

Table E.2- 3: Percentage of Flow to the NWFLR Based on Average Daily Flows (Regardless of Season).

Flow Source	FWO	ALT2	ALT5R	ALT10	ALT13	Historic
Lainhart Dam	52.6%	57.8%	58.6%	58.8%	57.4%	50%
Cypress Creek	35.8%	32.1%	31.3%	32.2%	32.2%	32%
Hobe Grove Ditch	4.6%	3.9%	3.9%	3.1%	4.0%	5%
Kitching Creek	7.0%	6.2%	6.2%	5.9%	6.4%	13%
Total	100.0%	100.0%	100.0%	100.0%	100.0%	100%

Table E.2- 2 and Table E.2- 3 represent the average daily tributary freshwater flow, regardless of season, per year throughout the POR for each alternative. For perspective, tributary freshwater flows were analyzed by season. Average daily freshwater flow entering the NWFLR via all tributaries combined increases from +13 cfs (ALT13) to +35 cfs (ALT10) (Table E.2- 2). Compared to the FWO, much of the improvement of freshwater flow to the NFLWR is through Lainhart Dam (ALT10 +6.2%, ALT5R +6.0%, ALT2 +5.2%, ALT13 +4.8%) (Table E.2- 3). All alternatives have reduced tributary contributions from Cypress Creek, Hobe Grove Ditch, and Kitching Creek compared to the FWO.

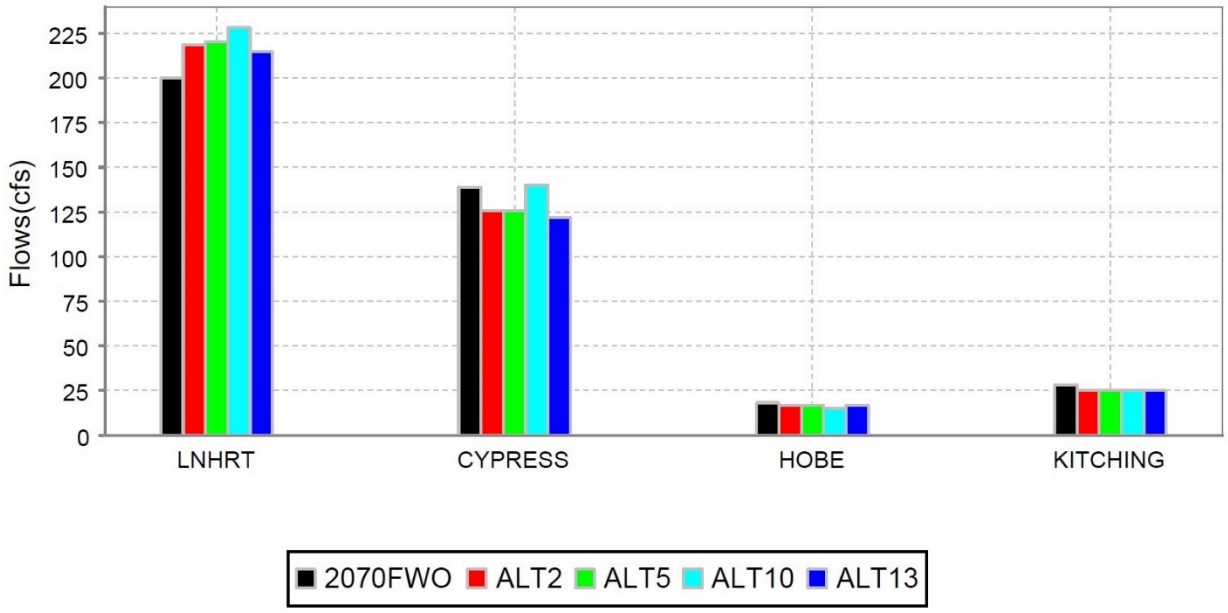


Figure E.2- 5: Wet Season Contribution of Average Daily Tributary Flows to the NWFLR (1965-2005).

Table E.2- 4: Wet Season Average Daily Flow to the NWFLR (cfs).

Flow Source	FWO	ALT2	ALT5R	ALT10	ALT13
Lainhart Dam	200	219	221	228	214
Cypress Creek	139	125	122	139	122
Hobe Grove Ditch	17	14	14	11	14
Kitching Creek	28	25	25	25	25
Total	384	383	382	403	375

Table E.2- 5: Percentage of Flow to the NWFLR Based on Wet Season Average Daily Flows.

	Percentage of Flow to NW Fork of Loxahatchee River (based on Wet Season AVG Daily Flows)				
Flow Source	**FWO**	**ALT2**	**ALT5R**	**ALT10**	**ALT13**
Lainhart Dam	52.1%	57.2%	57.9%	56.6%	57.1%
Cypress Creek	36.2%	32.6%	31.9%	34.5%	32.5%
Hobe Grove Ditch	4.4%	3.7%	3.7%	2.7%	3.7%
Kitching Creek	7.3%	6.5%	6.5%	6.2%	6.7%
Total	100%	100%	100%	100%	100%

Alternative performance for the average daily freshwater flow to the NWFLR during the wet season (Figure E.2- 5) differs from that of the average daily freshwater flow to the NWFLR regardless of season (Figure E.2- 4). ALT10 is the only alternative that increases freshwater flow (+19 cfs) to the NWFLR during the wet season compared to the FWO (Table E.2- 4). ALT2 has a slight decrease (-1 cfs) in total flow to the NWFLR during the wet season compared to the FWO, as does ALT5R (-2 cfs) and ALT13 (-9 cfs) (Table E.2- 4).

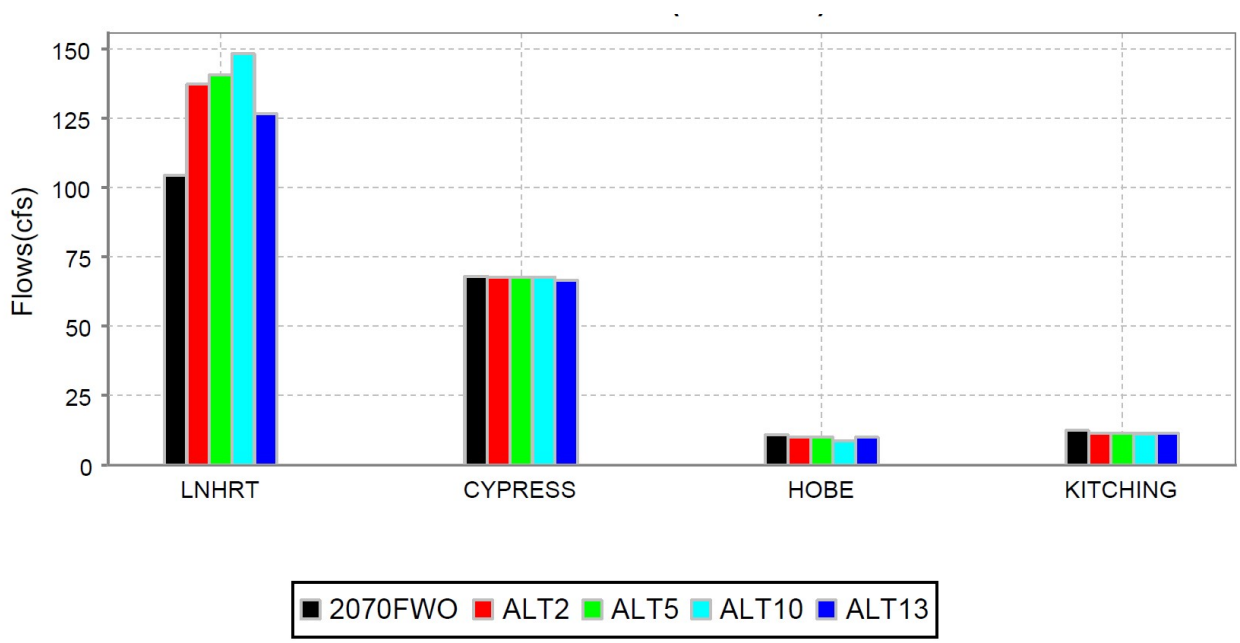


Figure E.2- 6: Dry Season Contribution of Average Daily Tributary Flows to the NWFLR (1965-2005).

As expected the average daily freshwater flow to the NWFLR during the dry season (Figure E.2- 6) are reduced compared to those of the wet season (Figure E.2- 5). Increases in freshwater flow to the NWFLR during the dry season via all tributaries ranged from +16 cfs (ALT13) to +36 (ALT10). Contributions of freshwater flow to the NWFLR during the dry season relies more heavily on flow through the Lainhart Dam compared to the tributaries for all alternatives and the FWO (Table E.2- 6).

Table E.2- 6: Dry Season Average Daily Flow to the NWFLR (cfs).

Flow Source	FWO	ALT2	ALT5R	ALT10	ALT13
Lainhart Dam	106	138	143	148	127
Cypress Creek	69	68	67	68	67
Hobe Grove Ditch	12	10	10	8	10
Kitching Creek	13	12	12	12	12
Total	200	228	232	236	216

Table E.2- 7: Percentage of Flow to the NWFLR Based on Dry Season Average Daily Flows.

Flow Source	FWO	ALT2	ALT5R	ALT10	ALT13
Lainhart Dam	53.0%	60.5%	61.6%	62.7%	58.8%
Cypress Creek	34.5%	29.8%	28.9%	28.8%	31.0%
Hobe Grove Ditch	6.0%	4.4%	4.3%	3.4%	4.6%
Kitching Creek	6.5%	5.3%	5.2%	5.1%	5.6%
Total	100%	100%	100%	100%	100%

Analysis from the 2006 Northwest Fork of the Loxahatchee River Restoration Plan states that the total volume of freshwater entering the system is the most important aspect of flow entering the Northwest Fork and not the amount entering through individual tributaries (SFWMD and FDEP). Therefore, the key performance metric regarding the restoration of freshwater flow to the NWFLR is average daily total flow. ALT10 increases freshwater flow to the NWFLR in both the wet and dry seasons compared to the FWO. All other alternatives (ALT2, ALT5R, ALT13) only increase freshwater flows, compared to the FWO, during the dry season. However, the increase in freshwater flows during the dry season overcomes the reduction in wet season daily freshwater flow rates for ALT2 (+28 cfs overall), ALT5R (+30 cfs overall), and ALT13 (+7 cfs overall) (Table E.2- 4 and Table E.2- 6).

Of note are the freshwater flow rates at Kitching Creek. As the most downstream tributary to the NWFLR, Kitching Creek flows into the NWFLR between RM8 and RM9 (Figure E.2- 1). Tidal push of salinity upstream during high tides results in a "mixing" zone at the confluence of Kitching Creek with the NWFLR (SFWMD and FDEP 2006). High tide pushes the freshwater entering the NWFLR from Kitching Creek upstream. Increased volume of freshwater through Lainhart Dam compensates for the flow reduction via Kitching Creek in all project alternatives (compared to the FWO). Therefore, the reduction of freshwater flow from Kitching Creek is not significant.

E.2.3.2 Objective 2: Restore Oysters, Seagrass, and Other Estuarine Communities

The 2006 Northwest Fork of the Loxahatchee River Restoration Plan states that field data analysis of the Loxahatchee River demonstrated a correlation between salinity throughout the NWFLR and the total amount of freshwater entering the NWFLR (Figure E.2- 7) (SFWMD and FDEP). Due to strong tidal mixing near the confluence with Kitching Creek, the source of freshwater flow entering the NWFLR is not an important factor for salinity regime. However, the total volume of freshwater flow entering the NWFLR is an important factor for salinity regime throughout the NWFLR.

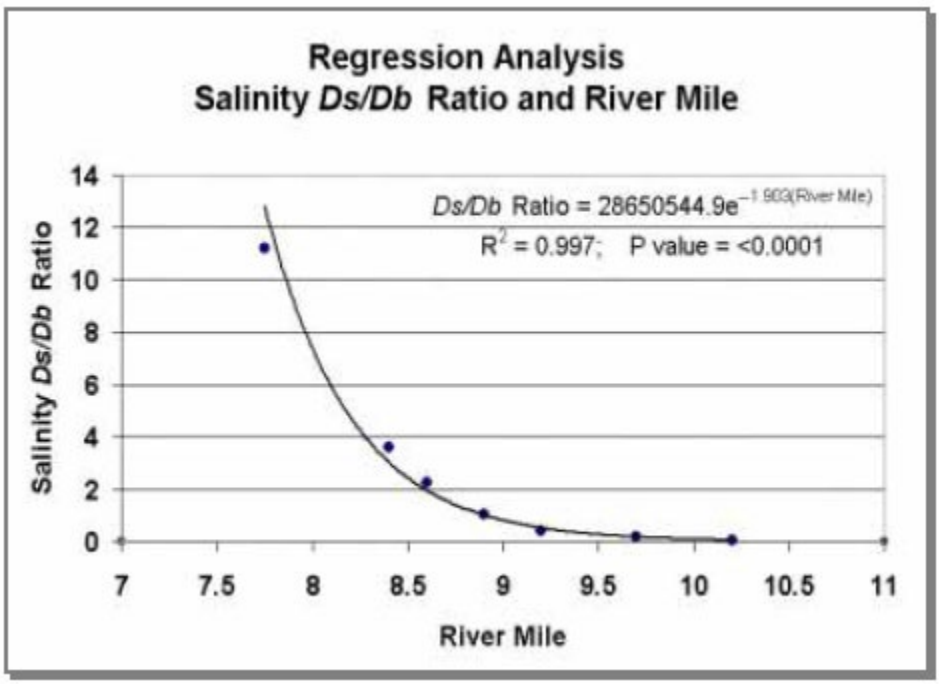


Figure E.2- 7: Correlation between Salinity Event Ratio Ds/Db (>1 ppt) and River Mile

(SFWMD and FDEP 2006). Ds is duration of all salinity events. Db is the duration between salinity events over time. Ds/Db is the salinity regime ratio of duration of all salinity events to the duration between these salinity events over time. (1 ppt, or psu is the threshold for inclusion).

Modeling data regarding salinity in the NWFLR for LRWRP alternatives has all freshwater flow to the NWFLR entering via the Lainhart Dam at approximately RM 14.5 (Figure E.2- 1), which represents freshwater flow input via the historic headwaters (Loxahatchee Slough) of the NWFLR. As previously

discussed, the source of freshwater flow to the NWFLR is not as important as the total amount of freshwater flow to the NWFLR (Section 2.3.1).

Evaluation of the modeling results for Objective 2 uses modeling data from ALT5 (formerly in the final array) and ALT13 to formulate the results for ALT5R (which was added to the final array in place of ALT5, but was not modeled) (Section E.1.3.4). As stated in Section E.2.3, analysis regarding any data influenced by Lainhart Dam utilizes modeling data from ALT5 and data related to the tributaries (Cypress Creek, Hobe Grove Ditch, and Kitching Creek) utilizes modeling data from ALT13. In this section, data for the Riverine Flood Plain VEC for ALT5R uses modeling results for ALT5. All other ALT5R VEC data uses ALT13 data. This is due to the downstream position of Riverine Flood Plain VEC in relation to all of the tributaries. Due to ALT5R having more total freshwater flow compared to ALT13 (Table E.2-2), the ecological and hydrological benefits in the objective 2 analysis for ALT5R are slightly underestimated.

Table E.2- 8: Salinity Performance Results from Performance Measure 1.

Obj.2 restore river, flood plain, estuary		Salinity Tool Performance Habitat Units (Acres)						Salinity Tool Performance %					
VECs	Total Area (Acres)*	ECB	FWO	ALT2	ALT5R	ALT10	ALT13	ECB	FWO	ALT2	ALT5R	ALT10	ALT13
Riverine Flood Plain**	483	314	314	420	440	459	386	65%	65%	87%	91%	95%	80%
Tidal Flood Plain	18	18	18	18	18	18	18	100%	100%	100%	100%	100%	100%
Valisneria	93	72	72	74	73	75	73	78%	78%	80%	79%	81%	79%
Oligohaline	161	35	34	38	37	39	37	22%	21%	23%	23%	24%	23%
Mesohaline	303	121	119	137	131	139	131	40%	39%	45%	43%	46%	43%
Polyhaline	731	675	673	671	672	667	672	92%	92%	92%	92%	91%	92%

**Flood Plain Acres and corresponding calculations are based on 30 day rolling average of dry season flows over 68 cfs (see Table E.2-9).

Table E.2- 9: Riverine Flood Plain Scoring Using 30 Day Rolling Average (Dry Season).

Scenario	30D Rolling Avg. Flow > 68cfs	Acreage of River Flood Plain	River Floodplain Restored Acres Per Alternative
ECB	0.65	483	313.95
FWO	0.65	483	313.95
ALT2	0.87	483	420.21
ALT5R	0.91	483	439.53
ALT10	0.95	483	458.85
ALT13	0.80	483	386.40

The **Riverine Flood Plain** (RM 16 to RM 9.5) still incurs a small amount of salinity mixing on the downstream end of the VEC where the target salinity is 0 practical salinity units (psu). The amount of salinity mixing on the downstream end (RM 9.5) of the **Riverine Flood Plain** VEC is markedly improved by all the LRWRP alternatives compared to the FWO (***Table E.2- 8***). ALT10 makes the most significant

improvement in the reduction of salinity mixing in the Riverine Flood Plain VEC, meeting the target of 0 psu for 95% of the riverine flood plain area (acreage) compared to just 65% of the riverine flood plain acreage for the FWO (***Table E.2- 8***). ALT13 meet 0 psu for only 80% of the riverine flood plain acreage which is still 15% higher than the FWO.

The **Tidal Flood Plain** (VEC (RM 9.5 to RM 8.1) has a salinity target of less than 2 psu. This target is met for 100% of the tidal flood plain acreage in all alternatives, as well as the ECB and FWO (***Table E.2- 8*** and ***Table E.2- 11***). This is not surprising giving the tidal mixing that occurs in this region. The confluence of Kitching Creek also occurs on the downstream end of this VEC. Freshwater entering the NWFLR is pushed upstream during high tides, keeping the salinity regime within the target range (< 2 psu). Thus, the **Tidal Flood Plain** VEC is not a factor in assessing LRWRP alternative performance.

To better understand the impacts of LRWRP alternatives on the NWFLR, data was parsed out by season (wet and dry) to provide insight into seasonal effects of LRWRP.

Table E.2- 10: Habitat Units (Acres) for Each VEC where Salinity Restoration Targets Were Met.

	POLYHALINE		Total Acres: 731	**MESOHALINE**		Total Acres: 303	**OLIGOHALINE**		Total Acres: 161	**VALLISNERIA**		Total Acres: 93	**TIDAL FLOOD PLAIN**		Total Acres: 18
Scenario	Dry	Wet	**Avg**	Dry	Wet	**Avg**	Dry	Wet	**Avg**	Dry	Wet	**Avg**	Dry	Wet	**Avg**
2014B	727	624	**675**	102	140	**121**	33	36	**35**	69	75	**72**	18	18	**18**
2070FWO	727	619	**673**	101	137	**119**	32	36	**34**	69	75	**72**	18	18	**18**
ALT2	722	619	**671**	128	145	**137**	39	36	**38**	73	75	**74**	18	18	**18**
ALT5R	724	620	**672**	118	145	**131**	37	37	**37**	71	75	**73**	18	18	**18**
ALT10	720	613	**667**	128	149	**139**	42	36	**39**	75	75	**75**	18	18	**18**
ALT13	724	620	**672**	118	145	**131**	37	37	**37**	71	75	**73**	18	18	**18**

Table E.2- 11: Percentage of VEC Acreage where Salinity Restoration Targets Were Met.

	Dry					Wet					Overall				
Scenario	P	M	O	V	T	P	M	O	V	T	P	M	O	V	T
2014B	99%	34%	20%	74%	100%	85%	46%	22%	80%	100%	92%	40%	21%	77%	100%
2070FWO	99%	33%	20%	74%	100%	85%	45%	22%	80%	100%	92%	39%	21%	77%	100%
ALT2	99%	42%	24%	79%	100%	85%	48%	23%	80%	100%	92%	45%	23%	80%	100%
ALT5R	99%	39%	23%	77%	100%	85%	48%	23%	80%	100%	92%	43%	23%	79%	100%
ALT10	98%	42%	26%	80%	100%	84%	49%	22%	80%	100%	91%	46%	24%	80%	100%
ALT13	99%	39%	23%	77%	100%	85%	48%	23%	80%	100%	92%	43%	23%	79%	100%

The ***Vallisneria*** VEC demonstrates no discernable difference among alternatives during the wet season (***Table E.2- 10*** and ***Table E.2- 11***). Thus, any difference between alternative performances is solely based on dry season flows. ALT10 outperforms the FWO and all other alternatives in meeting the salinity target of "less than 5 psu" from RM 10.5 to RM 6.5 (***Table E.2- 10*** and ***Table E.2- 11***).

The **Oligohaline Zone** VEC (RM 10 to RM 5.5) overlaps the ***Vallisneria*** VEC for 3.5 miles (RM 10 to RM 6.5). This overlap is important to the interpretation of model results for the **Oligohaline Zone**, as all project alternative and baseline scenarios (ECB and FWO) perform poorly for the restoration of acres within the 2 to 8 psu salinity range (***Table E.2- 10***). Restoration percentage within this overlap section of the NWFLR are high (79% to 80%) for the ***Vallisneria*** VEC (salinity < 5 psu) but low (23% to 24%) for the **Oligohaline**

Zone VEC (salinity between 2 and 8 psu). This suggests the salinity on the upstream side of the **Oligohaline Zone** VEC tends towards the lower salinity range (< 2 psu) (***Figure E.8- 2*** through ***Figure E.8- 4*** and ***Figure E.8- 7*** through ***Figure E.8- 9***). If salinity was between 2 psu and 5 psu on the upstream side, the restoration percentage would be high for both ***Vallisneria*** and **Oligohaline Zone** VECs. If salinity tended to be above 5 psu, restoration percentage would be higher for the **Oligohaline Zone** and low for the ***Vallisneria*** VEC in the overlap area. With modeling data revealing low percentages of restored acres (23% to 24%) in the **Oligohaline Zone** VEC (salinity 2 to 8 psu) combined with the high percentage of restored acres (79% to 80%) in the ***Vallisneria*** VEC (salinity < 2 psu), interpretation suggests that salinity tends towards the lower **Oligohaline Zone** threshold of 2 psu between RM 10 and RM 6.5.

LRWRP alternatives do not perform particularly well in the **Mesohaline Zone** VEC in meeting the salinity target of 10 to 20 psu. However, all alternatives outperform the FWO. All alternatives perform better in the wet season compared to the dry season, with much of the improvement in meeting the salinity target range is in the dry season (***Table E.2- 11***). Overall ALT10 meets the salinity target over 15% more acreage (20 acres) than the FWO and performs slightly better than all other alternatives overall. ALT2 achieves the salinity restoration target on 13% more acreage (18 acres) than the FWO. ALT5R and ALT13 achieve the salinity restoration target on 10% more acreage (12 acres) compared to the FWO.

All alternatives perform on par with the FWO, regardless of season, in the **Polyhaline Zone** VEC (RM 4 to RM 0) with FWO performing the best, meeting the target over 673 acres, and ALT10 performing the worst with the target met on 667 acres. All alternatives and the FWO meet the salinity target of greater than 20 psu over 90% of acreage in the **Polyhaline Zone** VEC (***Table E.2- 11***).

Modeling results for all ALTs, ECB, and FWO regarding the achievement of salinity restoration targets in each VEC is included in Section 8 (**pg. 56**).

E.2.4 Compatibility with RECOVER Northern Estuaries Goals and Targets

LRWRP is consistent with the ecological restoration targets established throughout the Northern Estuaries (NE) PMs. However, one structure, S-46, can have an impact on the salinity ranges found within the Loxahatchee Estuary. The S-46 structure discharges into the southwest fork of the Loxahatchee River and ultimately into the Loxahatchee Estuary. Most of LRWRP alternatives reduce average wet season flows through the S-46 structure (reduction of 1,520 ac-ft (ALT2), 140 ac-ft (ALT10), and 350 ac-ft (ALT13) compared to the FWO. However, ALT5R increases average wet season flow by 700 ac-ft compared to the FWO. The magnitude of these changes, increases or decreases, are considerably small. While most of the alternatives provide less wet season flows to the estuary which could result in decreased salinity, the magnitude of these changes are minimal (**Figure E.2- 8**). The same is true for the slight increase in wet season flow in ALT5R (**Figure E.2- 8**)

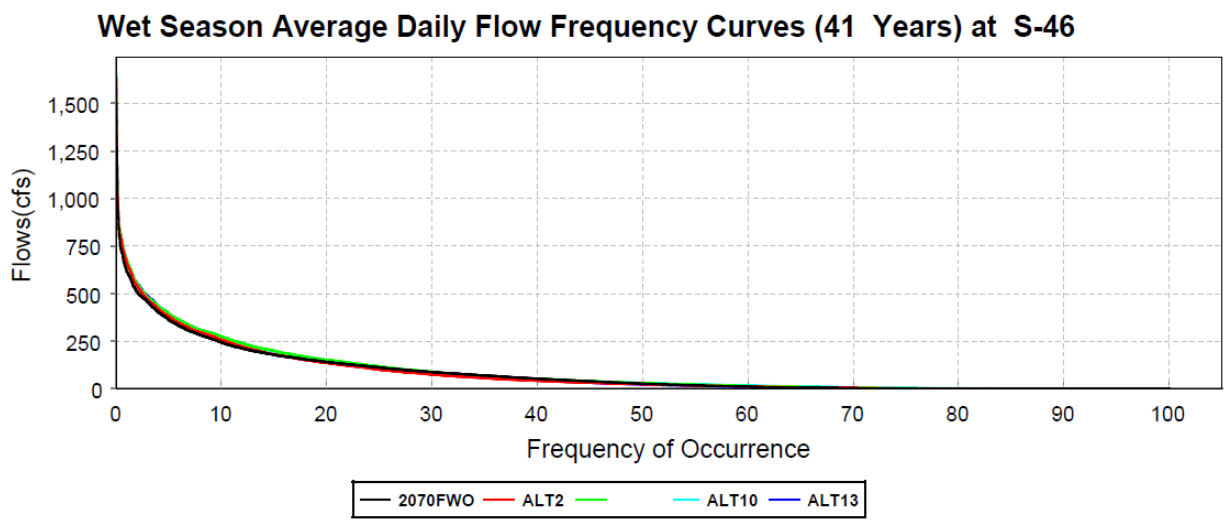


Figure E.2- 8: Comparison of LRWRP alternative wet season average daily flow compared to the FWO.

All of the LRWRP alternatives increase dry season flow through the S-46 structure improving dry season salinity conditions for flora and fauna utilizing the Loxahatchee Estuary. Dry season flow increases from 1,400 ac-ft (ALT2) to 2,520 ac-ft (ALT5R) compared to the FWO. Again, the magnitude of improvement is considerably small (**Figure E.2- 9**). Ultimately, salinity in the Loxahatchee Estuary will be influenced by S-46 flow as well as restored flows through the Northwest Fork of the Loxahatchee River.

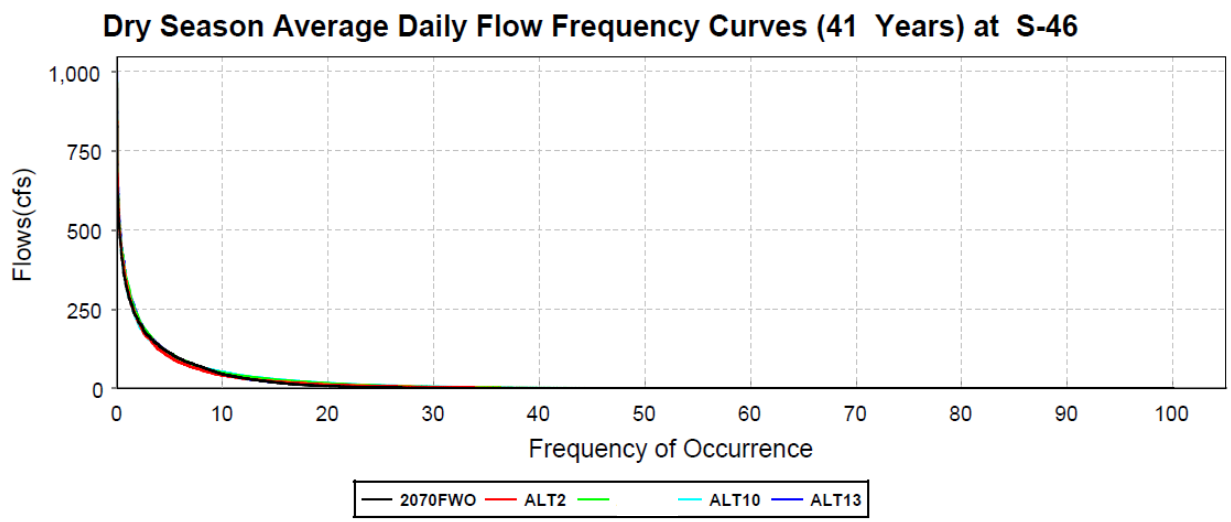


Figure E.2- 9: Comparison of LRWRP alternative average dry season daily flow compared to the FWO.

E.3.4 Summary and Conclusions

Objective 1 of the LRWRP is to "restore wet and dry season flows of water to the National Wild and Scenic Northwest Fork of the Loxahatchee River and the river floodplain." Scoring for objective 1 is based on the 30 day rolling average flow > 68 cfs (***Table E.2- 9***) as there was little separation in the performance of alternatives for the wet season. ALT10 outperformed all other alternatives in the restoration of dry season

flow to the NWFLR (***Table E.2- 1***). Of note, ALT10 performed the best of all alternatives in restoring wet season flow to the NWFLR as well (***Table E.2- 1***).

Table E-12: PM1 Scoring Rubric for Objective 2 (USACE and SFWMD 2015).

Score	Tidal floodplain	*Vallisneria Americana* (Manatee Grass)	Oligohaline Zone (Juvenile Fish)	Mesohaline Zone (Oysters)	Polyhaline Zone (Seagrass)
1	Salinity target met in 80-100% of the specified area	Salinity target met in 80-100% of the specified area	Salinity target met in 80-100% of the specified area	Salinity target met in 80-100% of the specified area	Salinity target met in 80-100% of the specified area
0.75	Salinity target met in 60-80% of the specified area	Salinity target met in 60-80% of the specified area	Salinity target met in 60-80% of the specified area	Salinity target met in 60-80% of the specified area	Salinity target met in 60-80% of the specified area
0.5	Salinity target met in 40-60% of the specified area	Salinity target met in 40-60% of the specified area	Salinity target met in 40-60% of the specified area	Salinity target met in 40-60% of the specified area	Salinity target met in 40-60% of the specified area
0.25	Salinity target met in 20-40% of the specified area	Salinity target met in 20-40% of the specified area	Salinity target met in 20-40% of the specified area	Salinity target met in 20-40% of the specified area	Salinity target met in 20-40% of the specified area
0	Salinity target met in <20% of the target area	Salinity target met in <20% of the target area	Salinity target met in <20% of the target area	Salinity target met in <20% of the target area	Salinity target met in <20% of the target area

Table E-12 shows the scoring rubric for LRWRP objective 2, "restore oysters, seagrass, and other estuarine communities in the Loxahatchee River Estuary" (USACE and SFWMD 2015). The scoring rubric (***Table E-12***) from PM1 was used to analyze the performance of each LRWRP alternative. Scores for each alternative were calculated by matching the VEC restoration percentage (***Table E.2- 8***) to the correct range for that VEC in the rubric and then averaging the rubric scores (column 1 above) for all the 5 VECs used in Objective 2 (Riverine Flood Plain restoration was Objective 1). If a restoration percentage score, i.e. 80%, fell in two separate rubric scoring categories, an average of the two rubric scores was used. For example, if the Oligohaline score was 80%, which falls in the rubric score categories of 1 and 0.75, the average score used is 0.875. For Objective 2, ALT2 and ALT10 equally outperformed ALT5R and ALT13 (***Table E.2- 13***). The RECOVER evaluation team conducting this review recommends the scoring methodology for PM1 be reevaluated and edited. The scoring ranges in the rubric are too wide resulting in less discernible results.

RECOVER recommends forgoing a scoring rubric and using percentage scores (which range from 0 to 1) as the scoring methodology for Objective 2 of PM1.

Overall, analysis of restoration alternatives for the LRWRP with respect to the NWFLR has shown that all project alternatives improve freshwater inputs for both wet and dry seasons compared to the FWO. In turn, the restoration of wet and dry season flows also show that all project alternatives improve the salinity conditions for most of the VECs within the Northwest Fork of the Loxahatchee River and Estuary when compared to the FWO. Of the project alternatives, ALT10 performs the best of the final array of alternatives in regards to the restoration of the NWFLR (PM1) for LRWRP (Table E.2- 13). Again, it is important to note that due to lack of modeling for ALT5R, the data used for scoring of ecological and hydrological improvements are underestimated for ALT5R in this analysis.

Table E.2- 13: Ranking of LRWRP ALTs Performance for PM1.

Restoration Alternative	Ranking for Objective 1	Ranking for Objective 2	Overall Ranking
FWO	0.65 (5)	0.65 (5)	0.65 (5)
ALT2	0.87 (3)	0.73 (1.5)	0.80 (3)
ALT5R	0.91 (2)	0.70 (3.5)	0.81 (2)
ALT10	0.95 (1)	0.73 (1.5)	0.84 (1)
ALT13	0.80 (4)	0.70 (3.5)	0.75 (4)

( ) denotes alternative ranking

E.4 LOXAHATCHEE WATERSHED

E.4.1 Introduction

This section evaluates Lower East Coast Sub-Regional Model (LECsR) predictions of the overall quantity, quality, timing, and distribution of freshwater for the Loxahatchee River watershed and adjacent wetlands associated with the Loxahatchee River Watershed Restoration Project (LRWRP) (Figure E.3- 1). This report also aims to provide a better understanding of the LRWRP's role in Everglades restoration as a whole.

Historically, the Loxahatchee River watershed included and drained more than 218 square miles of inland sloughs and wetlands. The drainage basin was comprised primarily of pine flatwoods interspersed with cypress sloughs, hardwood swamps, marshes, and wet prairies. Rainfall in the basin was directed through natural topography into the wetlands, treated by natural biological and chemical action, and slowly released to receiving water bodies (VanArman et al. 2005). The watershed was considered to fall within the eastern flatwoods landscape, which bordered the eastern side of the Everglades, from Lake Okeechobee to the New River (Figure E.3- 2). The eastern flatwoods landscape was only slightly elevated above the Everglades, and the Loxahatchee Slough served as a wetland connection between the Everglades and NWFLR. The Loxahatchee Slough may have historically provided water flow into, or

received outflow from, the Everglades depending on local rainfall. However, landscape patterns suggest the volumes were small. While not a principal outflow, the Loxahatchee Slough does appear to have provided a continuous aquatic connection between the northeastern Everglades and the Loxahatchee River. Early accounts report plentiful game including deer, bear, panther, and wading birds (McVoy et al. 2011).

Today, the Loxahatchee River Watershed is hydrologically disconnected from the Everglades. Approximately 168 square miles of the original watershed drains to the Atlantic Ocean through Jupiter Inlet. During the past sixty years, significant portions of the watershed have been converted from upland forests and wetlands to urban, residential and agricultural development (VanArman et al. 2005).

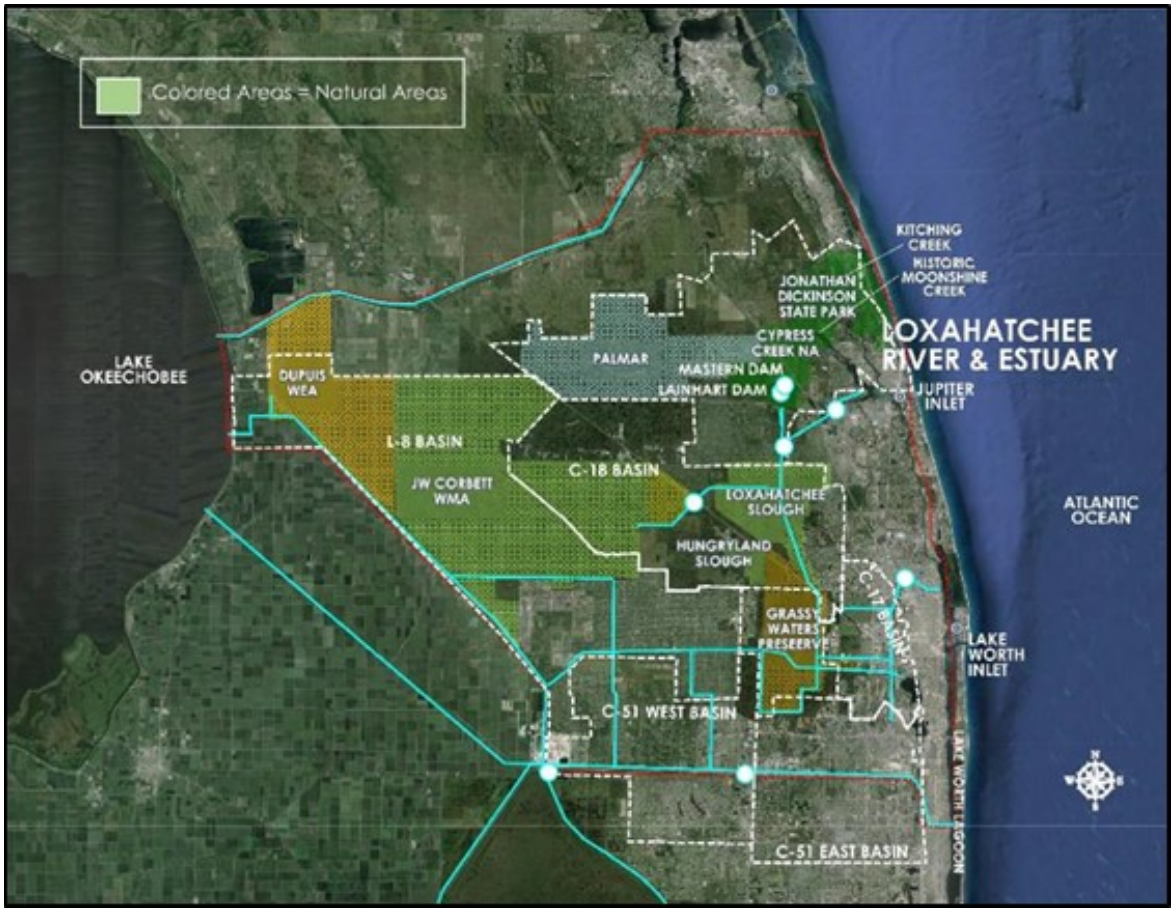


Figure E.3- 1: The LRWRP Project Area.

The study area is approximately 480,000 acres and includes the Loxahatchee River watershed and limited portions of the St. Lucie River watershed and Lake Worth Lagoon watershed.

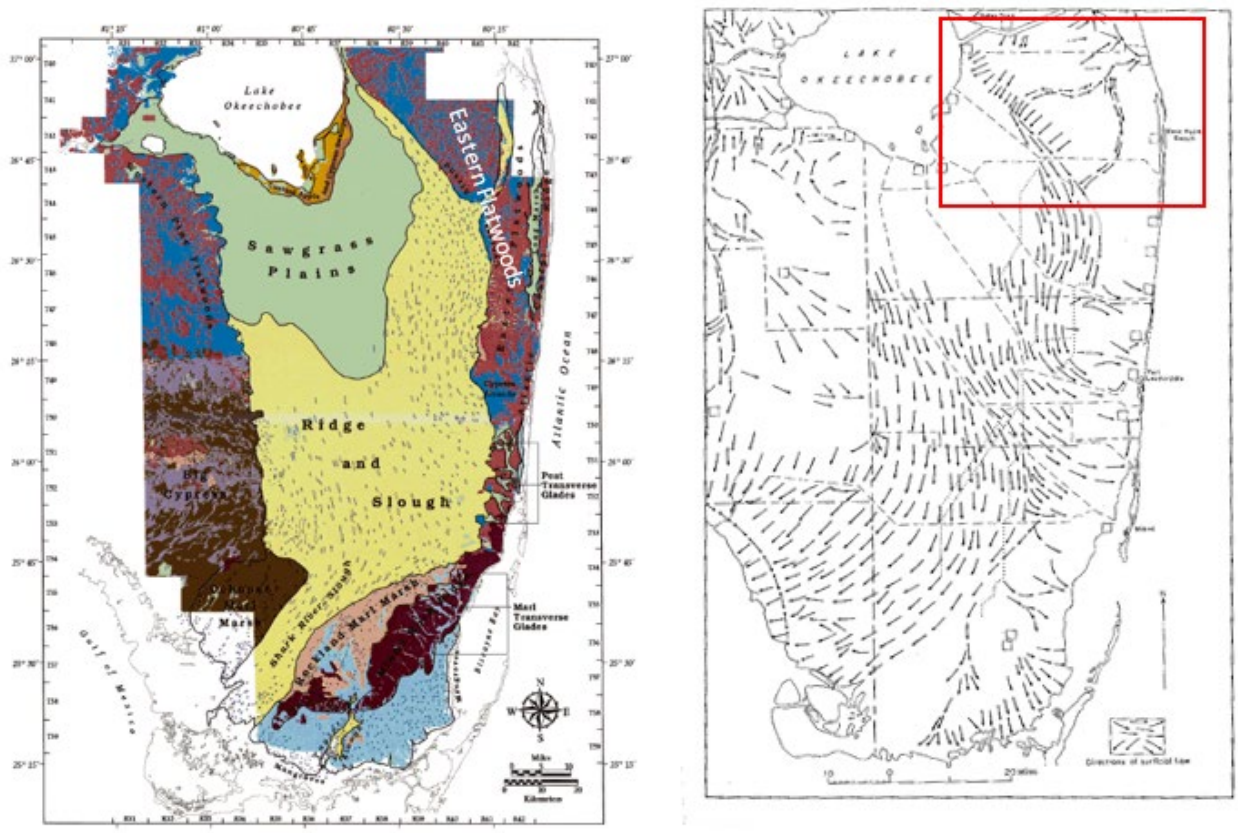


Figure E.3- 2: The map on the left shows the landscapes of the predrainage Everglades and bordering areas. The map on the right shows the directions of surface water flow under predrainage conditions. The red box indicates areas relevant to the LRWRP. Maps are modified from McVoy et al. 2011.

The LRWRP objectives include increasing natural area extent of wetlands in the watershed, restoring connections between natural areas, and restoring native plant and animal species abundance and diversity. The LRWRP objectives align with CERP goals, which include increasing the total spatial extent of natural areas, improving habitat and functional quality, and improving native plant and animal species abundance and diversity.

To assess the effects of the LRWRP, output from six modeling scenarios were compared. Modeling scenarios included ALT2, ALT5R, ALT10, and ALT13 (collectively referred to as ALTs), ECB, and FWO. The ECB represents the present configuration and operation of the water management system. The FWO scenario simulates a future configuration of the water management system without the LRWRP, but with other CERP projects that should benefit the overall system.

Two LRWRP PMs were used in the LRWRP plan formulation and evaluation, one is based on hydrologic targets, including duration of inundation, and the other is based on hydrologic and spatial connectivity. The two PMs are:

1. Hydrologic Regimes of Major Plant Communities in the Loxahatchee Watershed and Adjacent Wetlands (Watershed Hydrology)

2. Hydrologic/Spatial Connectivity (Connectivity)

E.4.2 Performance Measures and Evaluation Approach

E.4.2.1 Watershed Hydrology (PM 4)

One of the goals of the LRWRP is to improve vegetation communities and restore native plant and animal species abundance and diversity by achieving appropriate depth, duration and frequency targets in the Loxahatchee Watershed wetlands (USACE and SFWMD, 2014). Available data shows fifteen naturally-occurring vegetation communities are found within the Loxahatchee River watershed, including Jonathan Dickinson State Park (FNAI 1990, Roberts et al. 2006). Dominant communities include mesic and wet flatwoods, wet prairie, floodplain and dome swamp, depression marsh and mesic and hydric hammock. The species composition and distribution of plant communities in a given locale is a function of hydrologic regimes (depth of water table, length and frequency of inundation) as well as soil type, frequency of fire, and climate. Hydrologic restoration targets for each community type were determined by using data from literature supplemented by model output from unimpacted areas (including predevelopment and existing conditions).

The Watershed Hydrology performance measure determines the acres of restored wetlands from urban and agricultural land use to assess the increase in extent of natural areas (objective 3 – Table E- 2). Measurements are based on hydrologic regimes of major plant communities in the Loxahatchee Watershed and adjacent wetlands based on inundation durations. The proportion of days inundated out of the target number of days inundated yields the inundation duration score for each plant community. This was assessed for various indicator regions throughout the Watershed (Figure E.3- 3). The PM also uses Wetland Rapid Assessment Procedure (WRAP) Assessments, which produces a rating index for wetland sites that have been created, enhanced, preserved, or restored through the regulatory process. The WRAP rating index establishes a numerical ranking for individual ecological and anthropogenic factors (variables) that can influence the functionality of a natural system and the overall success of environmental projects. The final WRAP score is a numerical value between 0 and 1. As a general guideline, wetlands with WRAP scores ranging from 0.85 to 1.0 are high quality, 0.84-0.70 are medium high, 0.69-0.55 are medium, 0.54-0.40 are low quality and ≤ 0.39 are poor quality wetlands. The PM scores are determined by multiplying the inundation duration score and the functional scaling scare (WRAP score) by the total number of possible acres. A proportion of restored acres is used as the PM score for each alternative and flow way. Restoration of wetland hydrology will support restoration of fish and wildlife populations and diversity (objective 5 – Table E- 2). Grassy Water Preserve was not included in PM calculations since hydrology is a result of operations managed by the City of West Palm Beach.

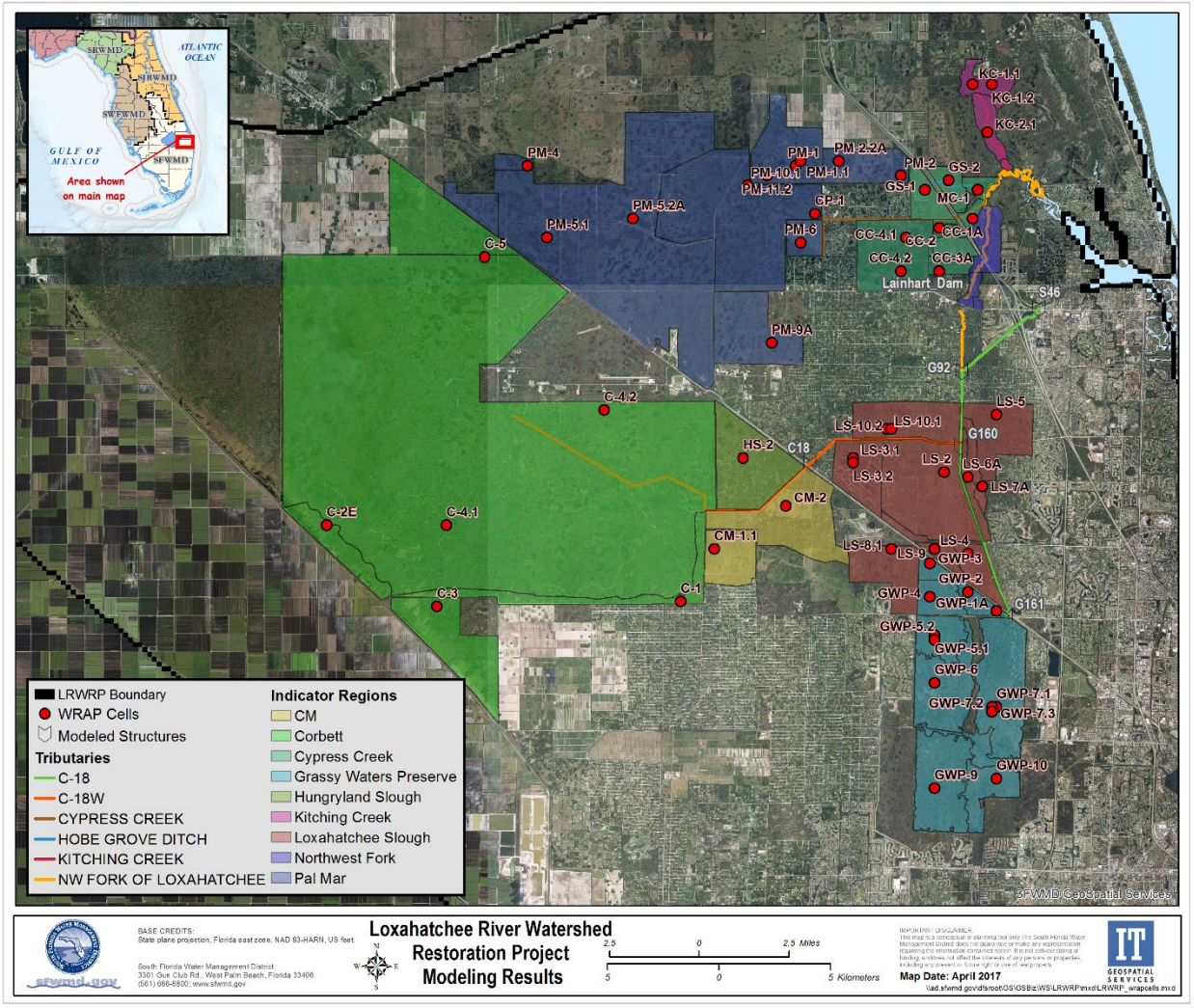


Figure E.3- 3: Indicator regions within the Loxahatchee River Watershed.

E.4.2.2 Connectivity (PM 9)

Hydrologic connectivity is essential to the ecological integrity of the landscape, and reduction or alteration by anthropological processes can have major negative environmental effects (Pringle, 2003). Establishment of new hydrologic connections in the landscape and restoration of connectivity in highly modified human-dominated landscapes can have species- to ecosystem-level effects (Pringle, 2003). Increasing the spatial extent of natural areas within the project study area, one of the three (3) major goals of the CERP (USACE and SFWMD 1999), will help to maintain and promote biodiversity by increasing available resources and habitat. Similarly, population and system dynamics would benefit from the hydrologic/spatial connectivity between protected lands by alleviating obstacles in the spread of native flora and wildlife movement between natural areas. Flora and faunal species would experience a spatial increase in suitable habitat and movement corridors and potentially, a larger reproductive gene pool due to the expansion of protected natural areas.

The Connectivity performance measure assesses potential benefits of reconnecting natural areas specific to four criteria (1-Hydrologic flow; 2-Greenway; 3-Water Quality; and 4-Endangered and/or Rare Species) (Objective 4). GIS layers were updated to add more quantitative information to support the overall qualitative approach to evaluating connectivity performance.

E.4.3 Evaluation

E.4.3.1 Watershed Hydrology

Compared to the FWO, most improvement was observed in FW3, except in ALT10, where most improvement occurred in FW1 (Figure E.3- 4 and Figure E.3- 5). Improvements in FW3 ranged from a 3% improvement in ALT10 to a 30% improvement in ALT13. FW1 also improved over all ALTs, increasing inundation duration and functionality of wetlands by 15% in ALT2, ALT10, and ALT13, to 16% in ALT5R. Across all alternatives, FW2 showed the least improvement compared to the FWO, decreasing performance of inundation duration and functionality of wetlands by 1% in ALT10 to increasing performance by 3% in ALT13 and ALT5R. Stage duration curves for indicator regions (IRs) in western FW2 showed stages consistently lower than targets, even with top-performing alternatives (Figure E.3- 6).

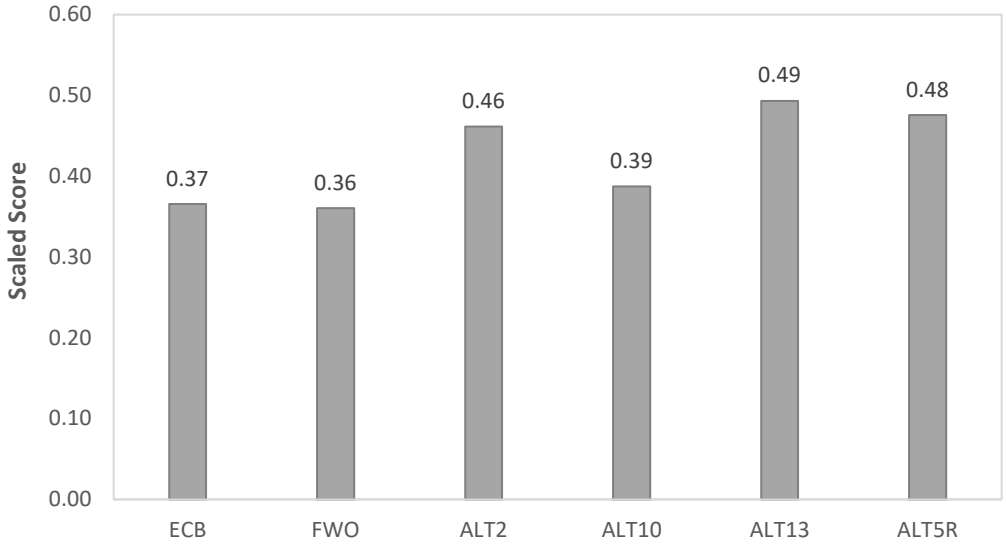


Figure E.3- 4: Scores for Watershed Hydrology PM.

A score of 0 is the worst score. A score of 1.0 the best score).

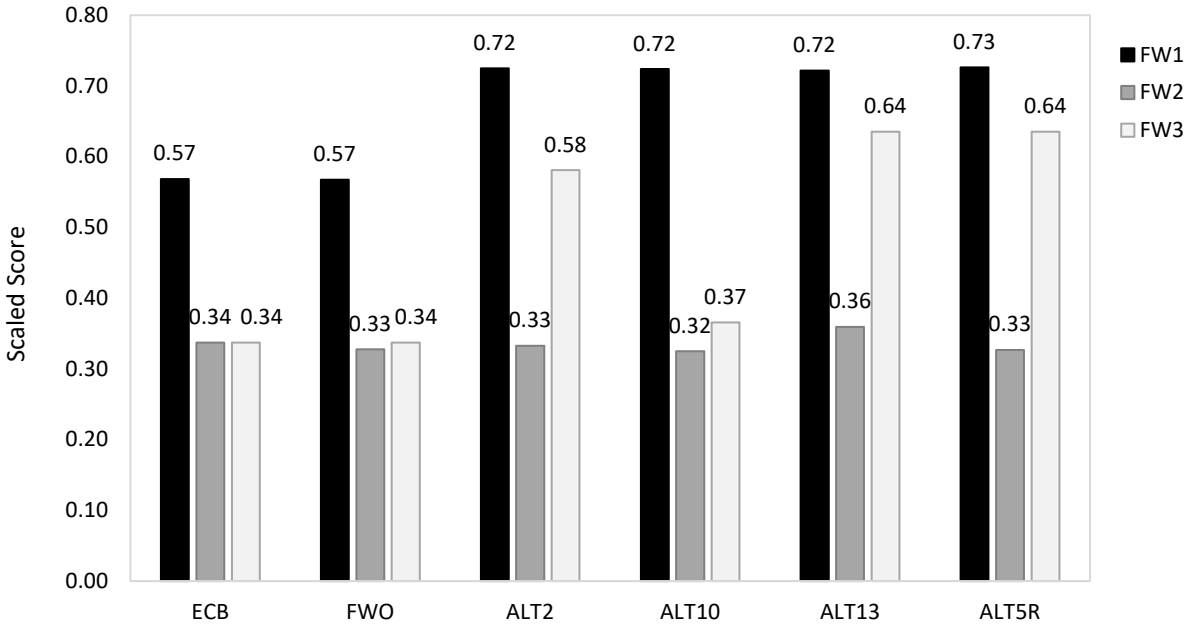


Figure E.3- 5: Scores for Watershed Hydrology PM by flow way.

A score of 0 is the worst score. A score of 1.0 is the best score.

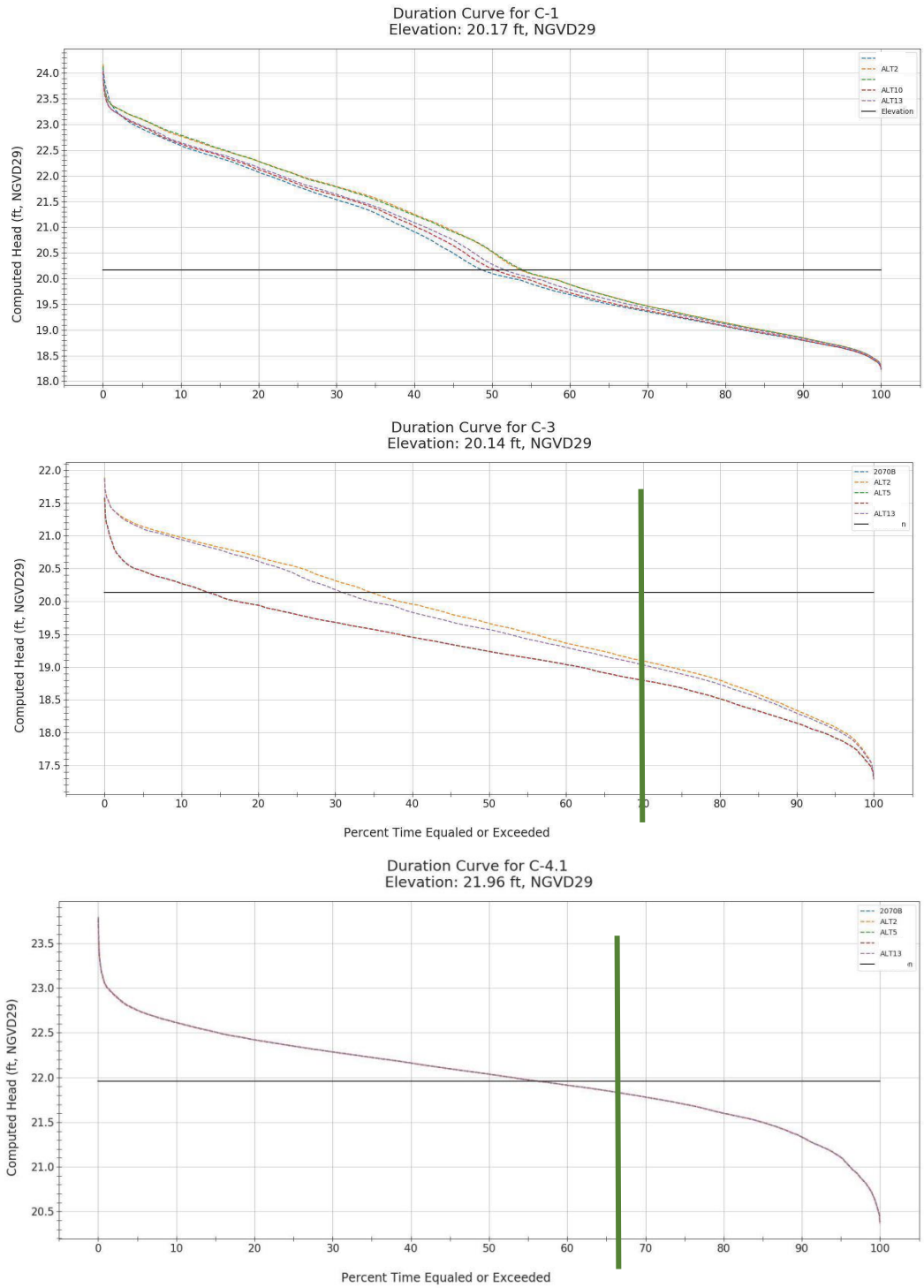


Figure E.3- 6: Stage Duration Curves for Indicator Regions in Western FW2.

The black line indicates the ground elevation. The target is indicated by the green vertical line. Best performance is indicated by above-ground water levels meeting target inundation duration. C-1 (top) is

considered to be a depression marsh with a target inundation of 66%. All ALTs fall below target, but perform better than the FWO. C-3 (middle) is considered to be a dome swamp with a target inundation of 70%. All ALTs fall below target. C-4.1 (bottom) is considered a depression marsh with a target inundation of 66%. All ALTs fall below target.

E.4.3.2 Connectivity

ALT13 improved the most above the FWO, while ALT 10 improved the least (Figure E.3- 7). ALT13 also showed the most improvement in all four criteria for connectivity. Greenway connectivity received the highest score, followed by water quality and fish and wildlife, and then hydrology (Figure E.3- 8). FW2 scores in ALT13 consistently performed the best, likely because of the C-18W Natural Storage feature (Figure E.3- 9). ALT13 results in a longer inundation duration than the target at indicator region CM-1, which has an inundation duration target intended to support vegetation for depression marsh. However, the range of water levels in ALT13 is more suitable for sawgrass, which is the community that commonly dominates depression marshes near the coast or where limestone is near the surface (FNAI 2010). ALT10 meets the target inundation for depression marshes, however water levels fluctuate between 5ft to 1ft below ground, which is not suitable for supporting sawgrass communities that commonly dominate depression marshes (Figure E.3- 10).

Fish and wildlife benefits may be underestimated in FW1 by the LRWRP team, considering the proximity of the area to wading bird colonies in northern Water Conservation Area 1. Additionally, Everglade snail kites consistently use the Grassy Water Preserve area for nesting and are likely foraging in the area. Consideration of this information would not change ranking of the ALTs, however.

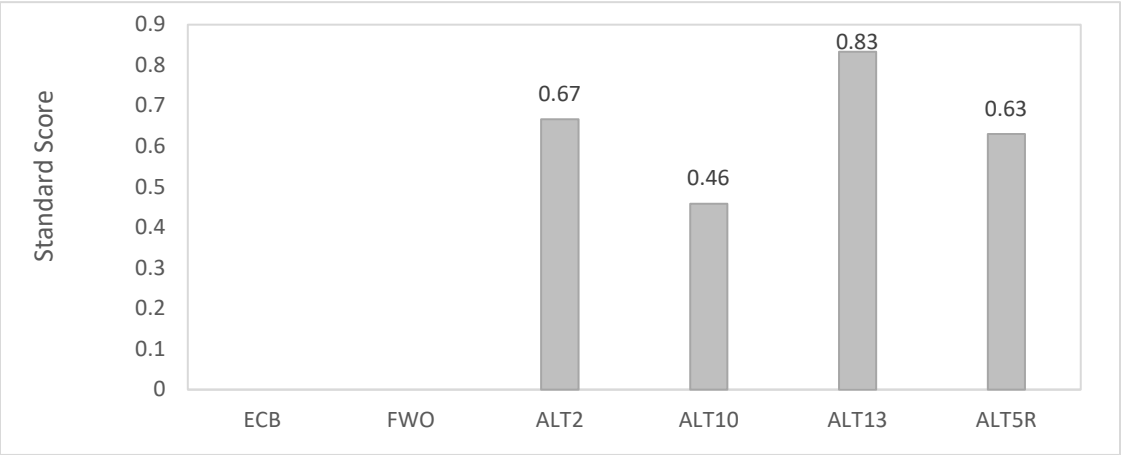


Figure E.3- 7: Scores for Connectivity PM.

A score of 0 is the worst score and a score of 1.0 is the best. Connectivity scores for the ECB and FWO are zero since connectivity is assumed to be the increment above the base condition.

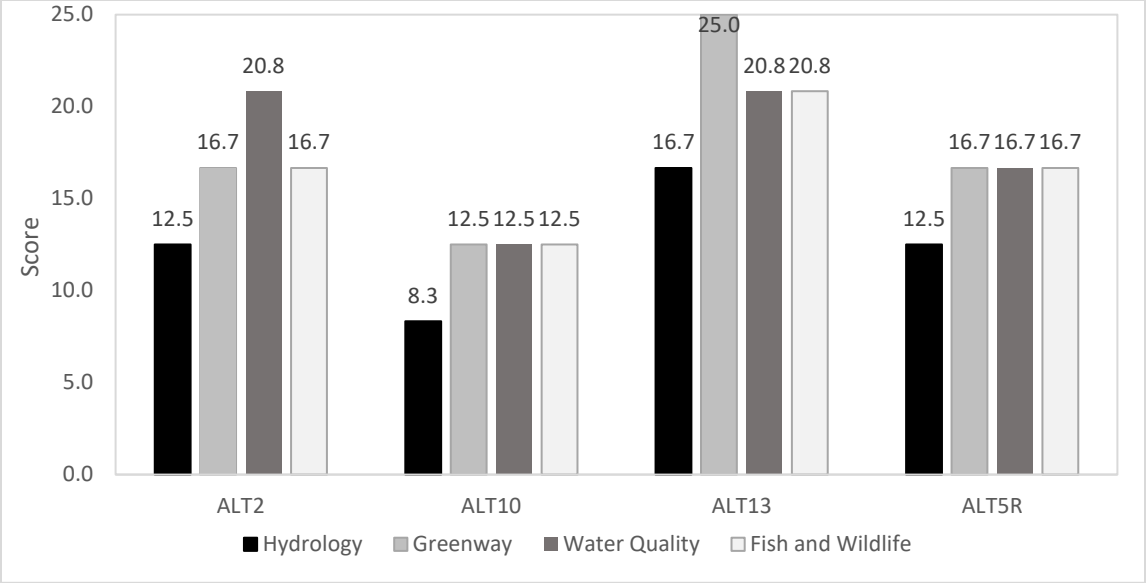


Figure E.3- 8: Scores for Each Criterion for Each Alternative.

Scores are averaged across flow-ways for each alternative. A score of 0 is the worst score and 25 is the best score.

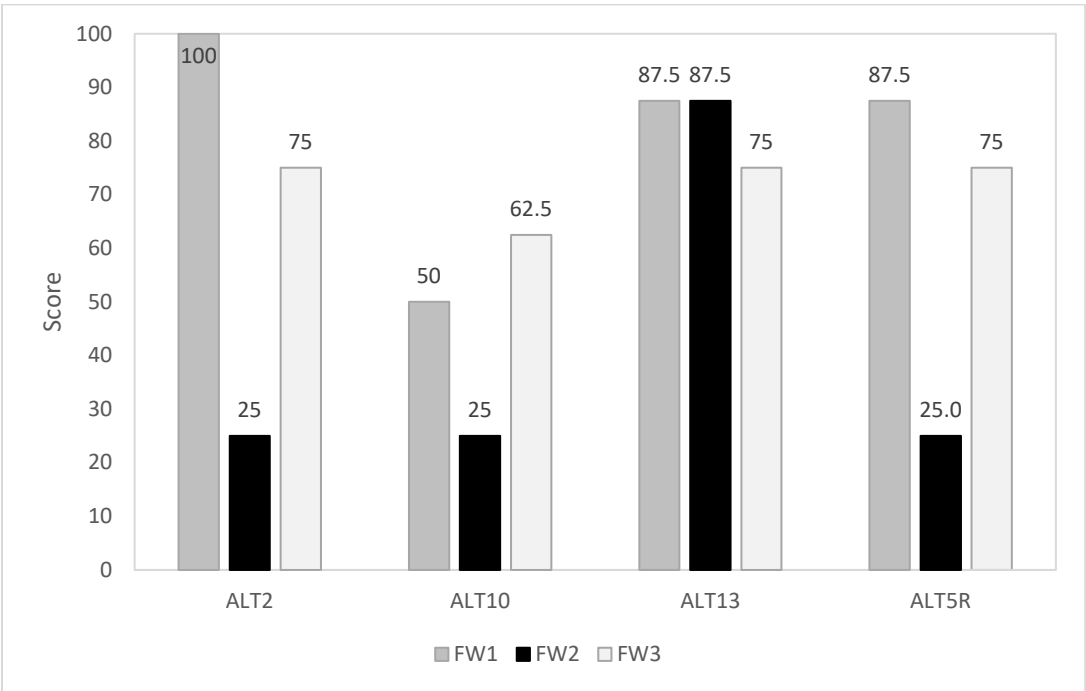


Figure E.3- 9: Criteria Combined by Flow Way.

A score of 0 is the worst score and 100 is the best score.

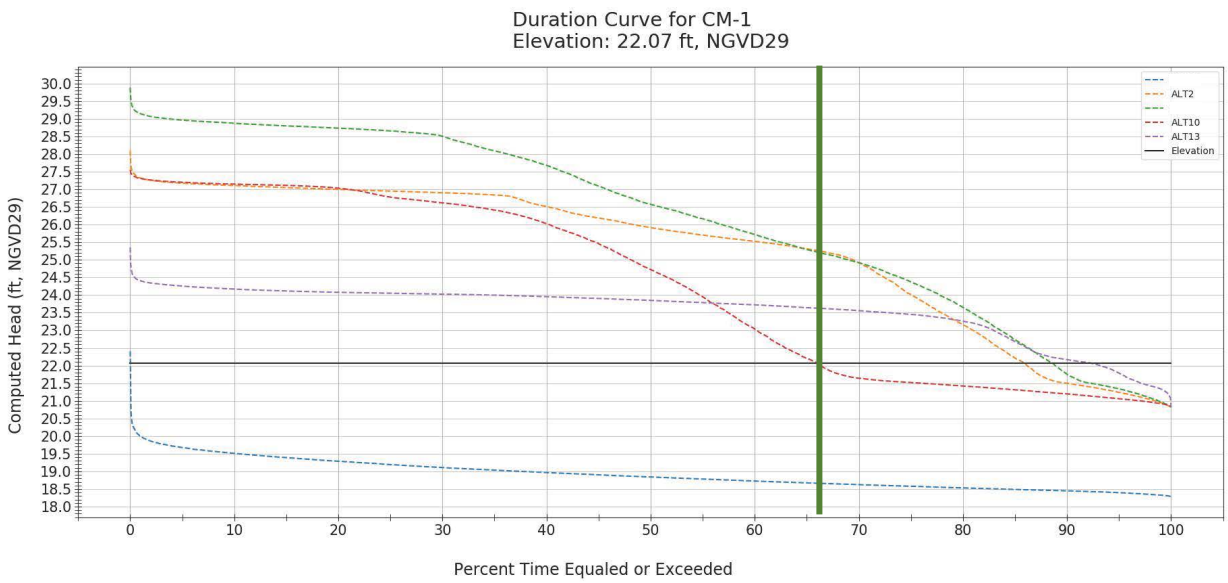


Figure E.3- 10: Stage Duration Curve for Indicator Region CM-1.

The black line indicates the ground elevation. The target is indicated by the green vertical line. Best performance is indicated by above-ground water levels meeting target inundation duration. CM-1 is considered to be a depression marsh with a target inundation of 66%.

E.4.3.3 Watershed Hydrology and Connectivity PM Scores Combined

The combined score for the Loxahatchee River watershed was highest for ALT13, followed by comparable scores for ALT5R and ALT2. ALT10 performed the worst. All projects ALTs improved watershed hydrology and connectivity compared to the FWO (Figure E.3- 11).

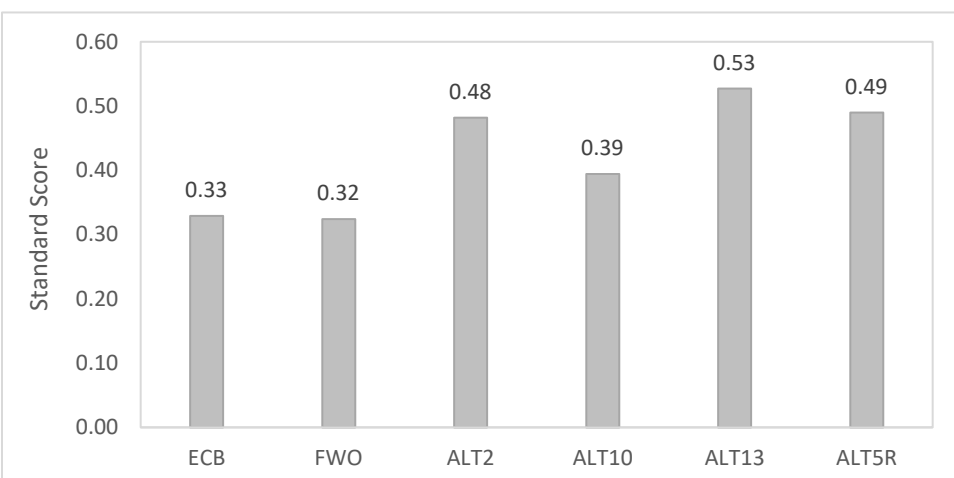


Figure E.3- 11: Scores for the Total Watershed.

A score of 0 is the worst score. A score of 1.0 is the best score. Scores from the watershed hydrology and connectivity PMs were combined and weighted 90% and 10%, respectively, to obtain the score for the total watershed.

E.3.4 Watershed Restoration and Connectivity to the Everglades

Though the historical hydrological connection between the Loxahatchee River and Everglades cannot be fully restored, restoration to the Loxahatchee River Watershed can still improve connectivity to the Everglades. Increasing the extent and quality of wetlands can also allow for progress towards restoration goals.

Defining characteristics are major ecological components that describe the pre-altered Everglades basin at large system-wide scales and collectively define the Greater Everglades ecosystem. Defining characteristics include 1) abundant large vertebrates and aquatic prey bases and 2) animals with large spatial requirements (Ogden et al. 2005). Species that exemplify defining characteristics, and use the LRWRP area, include wading birds (i.e. white ibis and wood stork), the Everglade snail kite, marsh fishes and crayfish (collectively referred to as aquatic fauna), and apple snails. (Figure E.3- 12).

Many of the species described below compose a suite of indicators that help to inform restoration progress. “Interim goals” for each indicator were developed to provide incremental goals which are expected to be met as restoration occurs. Species of concern in the LRWRP area are also discussed.

E.3.4.1 Wading Birds

Data for wading bird nesting and foraging locations were provided by the U.S. Fish and Wildlife Service (USFWS) (Figure E.3- 12) and informed by the 2018 South Florida Wading Bird Report (Cook and Baranski 2018). Several colonies within and around the project area were identified as colonies potentially impacted by the LRWRP. Colonies included Ballen Isles, Wakodahatchee Wetlands, Palm Beach Natural Areas, and Water Conservation Area (WCA) 1. Improved hydrological conditions and quality of foraging area within the LRWRP boundary can provide nearby colonies with food resources needed to initiate and sustain reproductive processes (Frederick and Collopy 1989, Frederick and Spalding 1994). Wood storks (*Mycteria americana*) will forage up to 50 km (Herring and Gawlik 2011), while small herons forage up to 30 km (Strong et al. 1997) from their colonies. Considering their foraging distances, much of the LRWRP area is available to these birds. Interim goals for wading birds, relevant to the LRWRP, consider system-wide patterns of nesting, including measurements of number of breeding pairs, timing of wood stork breeding, and frequency of “super colonies”.

E.3.4.2 Everglade Snail Kite (*Rostrhamus sociabilis plumbeus*)

The snail kite is an endangered species characteristic of the Everglades, living in wet prairie habitats with tree islands. It has experienced dramatic population changes over the past 20 years. Three features that remain consistent within the selected habitats are the presence of apple snails, sparsely distributed emergent vegetation, and suitable nesting substrates. The USFWS has identified recovery criteria related to population size, population growth rate, and extent of foraging habitat (Fletcher et al. 2018). The Everglade snail kite has also been documented within and around the LRWRP area (Figure E.3- 12).

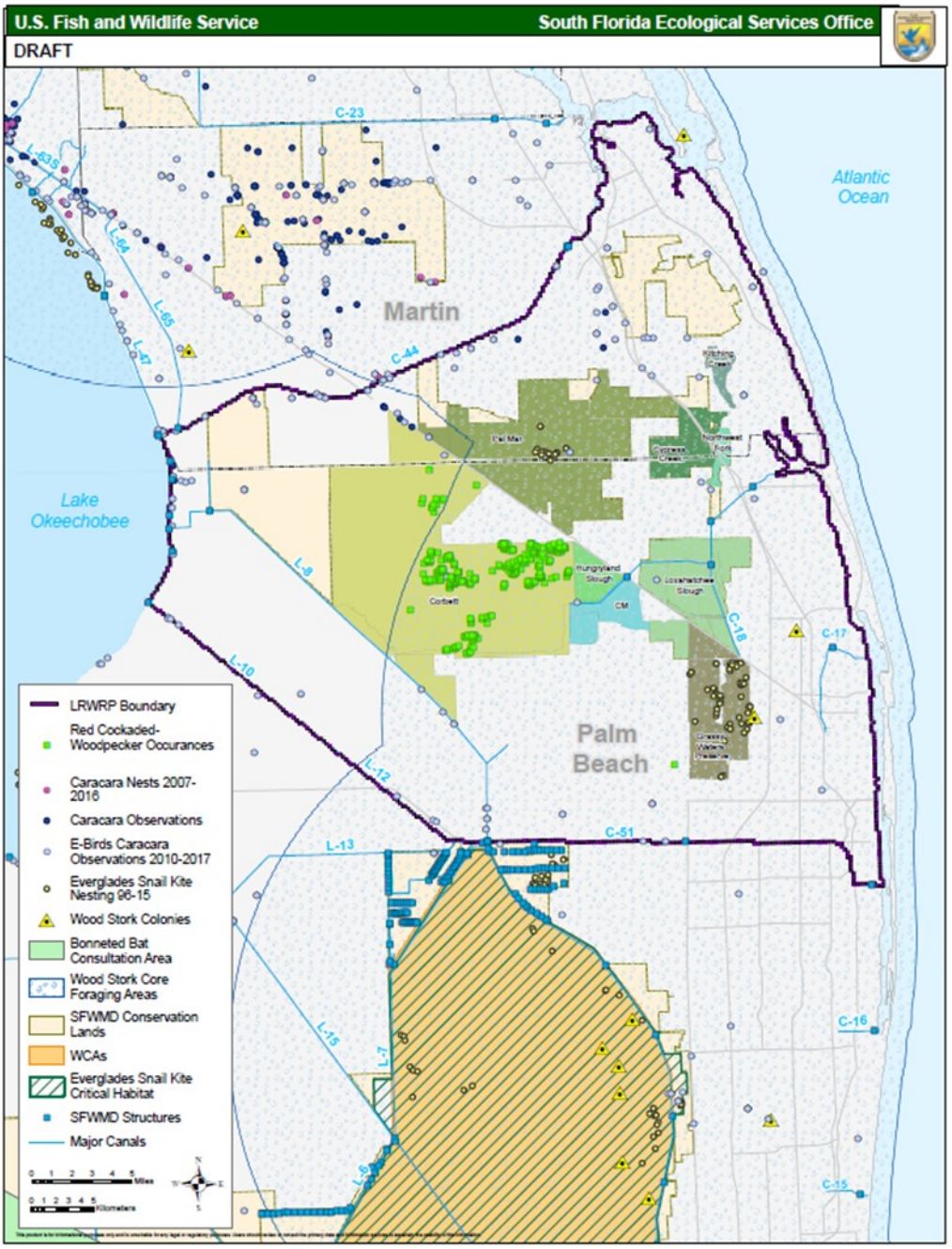


Figure E.3- 12: Species Occurrence within the LRWRP and Adjacent Areas.

E.3.4.3 Red-Cockaded Woodpecker (*Leuconotopicus borealis*)

The red-cockaded woodpecker is an endangered species found in the longleaf pine ecosystem. Recovery criteria are related to increased population sizes and potential breeding groups (USFWS 1985). Several observations have been documented in the Corbett Wildlife Management Area. Improved habitat and re-

establishment of historical vegetation as a result of LRWRP may be able to facilitate the success of potential breeding groups as the extent of favorable groundcover increases (Figure E.3- 12).

E.3.4.4 Crested Caracara (*Caracara cheriway*)

The caracara is a threatened species found in open prairie, pastures, or open rangeland, preferably with cabbage palmettos for roosting. The main threat to caracara is habitat loss. Prey species can include small mammals, amphibians, reptiles, fish crabs, invertebrates, and young birds. Restoration as a result of the LRWRP can improve habitat quality, particularly for aquatic prey species, for the caracara and facilitate expansion into areas that become more suitable. Several observations of caracara have been documented around and within the LRWRP area (Figure E.3- 12).

E.3.4.5 Aquatic Fauna

Fish and freshwater crustacean community structure are very sensitive to hydrological conditions. Research has linked three key aspects of Everglades' ecology to this indicator: (1) top predators, such as wading birds, are directly dependent on prey density, especially fish and crustaceans; (2) prey population structure, standing crop, and density are directly dependent on periphyton biomass, water depth, quality and distribution, the timing of seasonal concentrations, and duration of drought conditions; (3) prey availability is directly dependent on prey density, water depth, timing of seasonal concentrations and duration of drought conditions (Trexler and Goss 2009).

Data for aquatic fauna from 2005 to 2006 were provided by RECOVER. Monitoring sites were located within the Pal Mar area (Figure E.3- 13). Pal Mar contributed a relatively large percent (30%) of mollusks, non-fish vertebrates, and other invertebrates (mostly dragonfly nymphs) to the average standing crop. Notably, this area had high densities of crayfish (Figure E.3- 14).

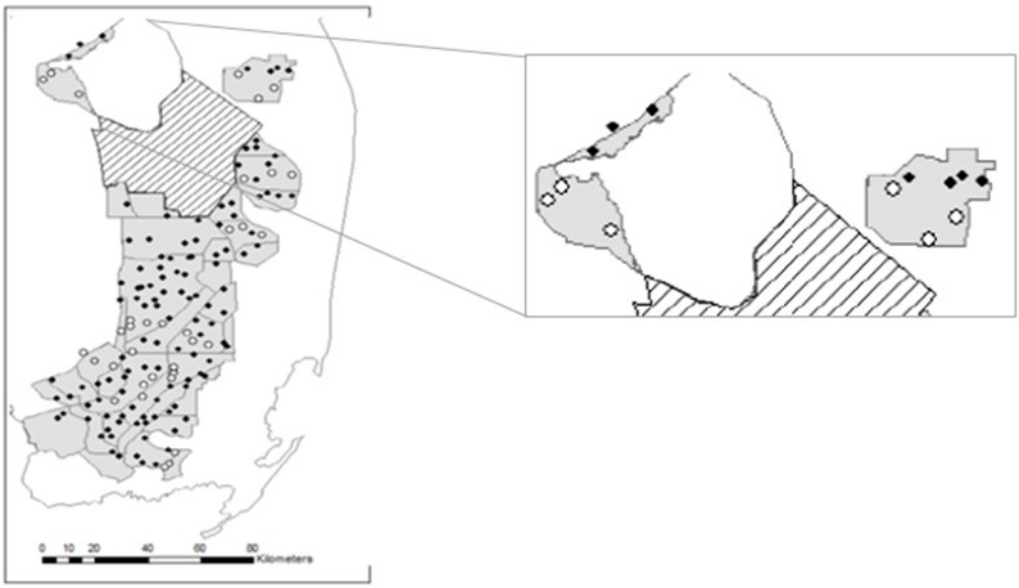


Figure E.3- 13: Sampling Locations for Aquatic Fauna in the Everglades and Adjacent Areas from 2005-2006.

Dark circles are sites sampled only during the wet season. White circles are sites sampled during both wet and dry seasons.

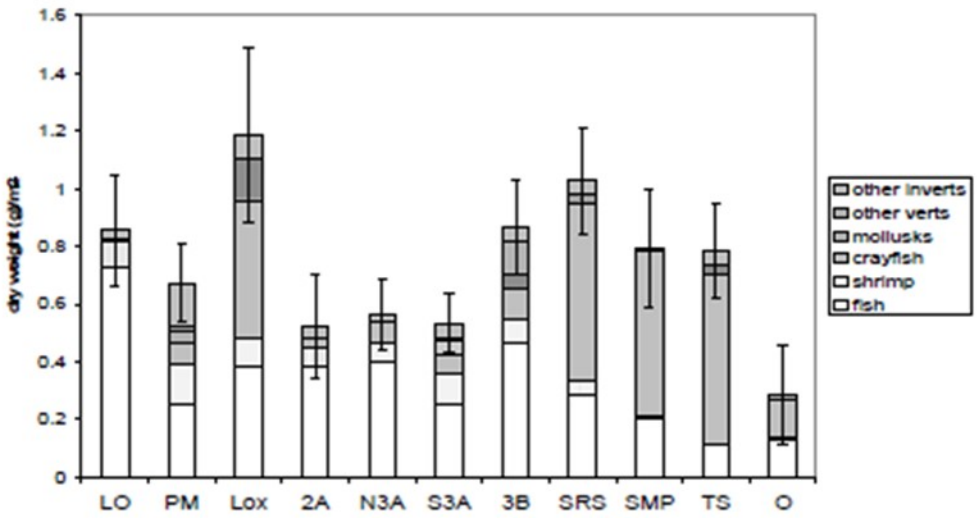


Figure E.3- 14: Average Standing Crop per Region of Aquatic Fauna Prey Population during the 2005 Late Wet Season, Broken Down by Taxonomic Category (Trexler and Robertson 2006).

Error bars are one standard error of the mean of the standing crop for each region. Location Abbreviations: LO- Lake Okeechobee; PM-Pal Mar; 2A- WCA 2A; 3B – WCA 3B; SRS- Shark River Slough; SMP-Southern Marl Prairies; TS- Taylor Slough; O – Ochopee Marl Prairie. Pal Mar is the only sampling location within the LRWRP area (Trexler and Robertson 2006).

The diversity of habitats and prey in this area may provide alternative foraging habitats when conditions are less favorable in the WCAs. During periods of high rainfall, the higher ground elevations in the LRWRP area may allow for suitable depths for foraging species when water levels in the WCAs are too deep. Additionally, in some years, areas within the LRWRP provide higher prey biomass per m^2 than WCA 2 and 3 (Figure E.3- 14). Over the past several years, monitoring has suggested the number of small herons is severely declining in the Everglades (Cook and Baranski 2018). Differences among regions in biomass are probably the result of interaction of recent hydrological history (time since the most recent drying event and spatial pattern of drying in the region relative to sampling site placement) long-term management history (frequency of drying events over the past several years), biogeochemical status of the area and access to permanent aquatic refuges such as canals. Improved habitat as a result of the LRWRP may provide sufficient food resources and improve nesting numbers since the area offers a diverse array of prey species, which small herons have been documented to consume (Klassen et al. 2016).

E.4.4 Summary and Conclusions

For the watershed hydrology and connectivity PMs, ALT10 performed noticeably worse than other LRWRP ALTs, most likely due to performance in the Cypress Creek and Pal Mar indicator regions (Table E.3- 1). Low scores may be a result of the exclusion of the Gulfstream West and Pal Mar East features in this ALT. High performance of ALT13 was attributed to consistently higher FW2 scores, which may be a result of hydrological improvements associated with the C-18W Natural Storage feature (Figure E.3- 5). Stage duration curves for indicator regions in western FW2 showed stage duration consistently lower than

targets, even with top-performing alternatives. However, LRWRP ALTs showed improvement over the FWO. Fish and wildlife benefits may be underestimated in FW1 by the LRWRP team, considering the proximity of FW1 to wading bird colonies in northern Water Conservation Area 1 and the consistency of snail kite nesting within the Grassy Water Preserve area. However, this would not affect the ranking of alternatives. These species along with aquatic fauna in the regions may provide benefits to the Everglades restoration by providing improved habitat for species and may result in further movement towards restoration interim goals.

Though the historical hydrological connection between the Loxahatchee River and Everglades cannot be fully restored, restoration to the Loxahatchee River Watershed can still improve connectivity to the Everglades. Increasing the extent and quality of wetlands can allow for progress towards restoration goals. The LRWRP is expected to improve conditions for a number of indicators (wading birds, marsh fish, and snail kite) and listed species residing within and near the project area. Increased extent and quality of foraging conditions for ecological indicators can also support progress towards meeting interim goals.

Table E.3- 1: Ranking of LRWRP ALTs Performance for PMs 4 and 9.

Performance Metric	FWO	ALT2	ALT5R	ALT10	ALT13
PM-4 Watershed Hydrology	0.36 (5)	0.46 (3)	0.48 (2)	0.39 (4)	0.49 (1)
PM-9 Connectivity	0* (5)	0.67 (2)	0.63 (3)	0.46 (4)	0.83 (1)
Total Watershed	0.32 (5)	0.48 (3)	0.49 (2)	0.39 (4)	0.53 (1)

*****Connectivity scores for FWO are zero since connectivity is assumed to be the increment above the base condition
( ) denotes alternative ranking

E.5 LAKE OKEECHOBEE LAKE STAGE

E.5.1 Introduction

ALT 10 includes construction of the C-51 deep reservoir feature, which would reduce water deliveries, via the L-8 canal, from Lake Okeechobee to the project area. This would incrementally reduce the discharge opportunities from Lake Okeechobee and the Herbert Hoover Dike. The L-8 canal is a relatively small canal used primarily for water supply (SFWMD 2010). The Lake Okeechobee section evaluates the potential effects of ALT10 on lake stages and the ecology of the Lake Okeechobee system. Other LRWRP alternatives are not considered in the analysis since they are not expected to affect water deliveries or lake stage because they do not include the C-51 deep reservoir feature.

A wide body of published research (summarized in Havens 2002) documents the ecological benefits of seasonally variable water levels within the range of 12.0 feet (ft) NGVD, in June and July, and 15.0 ft, from November to January. Falling water levels in late winter to spring benefit wading birds by concentrating prey resources in the littoral zone where those birds forage (Smith et al. 1995), water levels near 12.0 ft benefit submerged plants and bulrush by providing optimal light levels for photosynthesis in the summer months (Havens et al. 2004), and variation in the prescribed range results in annual flooding and drying

of upland areas of the littoral zone, which favors development of a diverse emergent plant community (Richardson et al. 1995, Keddy and Frazer 2000). However, periodic low stage events (11 ft NGVD) occurred approximately once per decade at a duration of roughly three months in the 1950s to 1970s (prior to implementation of high stage regulation schedules), and are considered beneficial to the littoral zone because they allow for periodic exposure of seed banks, oxidation of accumulated organic material, and fires that are important to maintaining species diversity in the littoral zone.

E.4.2 Performance Measures and Evaluation Approach

There were no performance measures developed to assess the effects of LRWRP on Lake Okeechobee. Instead, monthly average outflow data from the C-10A culvert were evaluated. The C-10A culvert releases water into the L-8 canal. Monthly outflow rates were converted to acre-feet to describe the volume of water released from the lake. One acre-foot of water is equivalent to 43,560 cubic feet A flow rate of one cubic foot per second (cfs) over one day will result in 1.98 acre feet per day.**E.4.3 Evaluation**

Flow data from the last ten years were evaluated to determine the effects on lake stage if flow was reduced from the C-10A culvert into the L-8 canal. The average monthly flow and volume of water conveyed through the C-10A culvert is presented in Table E.4- 1 and ***Table E.4- 2***, respectively.

Table E.4- 1: Outflows (cfs) through the C-10A Culvert into the L-8 Canal over the Past Ten Years.

Values of 0 indicate months that no releases into the L-8 canal occurred.

Months / Year	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
1	0	270.419	96.061	105.997	219.935	392.935	243.968	357	130.116	248.59	146.496
2	0	213.571	39.496	135.75	118.552	330.929	205.911	367.519	20.13	189.996	257.214
3	0	101.787	133.774	90.065	80.423	320.645	220.355	306.2	170.981	126.703	282.935
4	0	8.19	313.1	59.7	29.038	267	70.103	250.267	198.393	0	157.637
5	0.207	0	363.613	46.956	0	145.419	0	199.355	250.581	0	0
6	0	0	273.1	12.043	0	0	0	7.83	277.6	0	0
7	0	0	259.968	0	0	0	0	0	380.194	0	0
8	0	131.839	197.435	0	625.581	485.29	316.129	0	181.178	0	0
9	46.9	195.367	104.4	0	112.356	306.733	183.393	0	122.362	0	0
10	79.548	254.71	164.742	0	112.356	394.452	117.032	288.839	95.509	0	0
11	349.667	238.137	164.847	0	218.067	374.333	196.933	218.967	256.067	6.594	0
12	312.824	121.748	183.903	88.103	373.387	304.839	282.355	207.258	327.174	1.271	0

Table E.4- 2: Additional Volume (Acre-Feet) of Water in Lake Okeechobee if Outflows through the C-10A Culvert into the L-8 Canal Did Not Occur.

Values of 0 indicate months that no releases into the L-8 canal occurred.

Months	Years										
	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
1	0.0	536.4	190.5	210.2	436.2	779.4	483.9	708.1	258.1	493.1	290.6
2	0.0	423.6	78.3	269.3	235.1	656.4	408.4	729.0	39.9	376.9	510.2
3	0.0	201.9	265.3	178.6	159.5	636.0	437.1	607.3	339.1	251.3	561.2
4	0.0	16.2	621.0	118.4	57.6	529.6	139.0	496.4	393.5	0.0	312.7
5	0.4	0.0	721.2	93.1	0.0	288.4	0.0	395.4	497.0	0.0	0.0
6	0.0	0.0	541.7	23.9	0.0	0.0	0.0	15.5	550.6	0.0	0.0
7	0.0	0.0	515.6	0.0	0.0	0.0	0.0	0.0	754.1	0.0	0.0
8	0.0	261.5	391.6	0.0	1240.8	962.6	627.0	0.0	359.4	0.0	0.0
9	93.0	387.5	207.1	0.0	222.9	608.4	363.8	0.0	242.7	0.0	0.0
10	157.8	505.2	326.8	0.0	222.9	782.4	232.1	572.9	189.4	0.0	0.0
11	693.6	472.3	327.0	0.0	432.5	742.5	390.6	434.3	507.9	13.1	0.0
12	620.5	241.5	364.8	174.7	740.6	604.6	560.0	411.1	648.9	2.5	0.0

Monthly average releases were 138.2 cfs, which is equivalent to an average of 274.0 acre feet per day, or an average of 8,190 acre feet per month. The largest monthly average release occurred in October 2013 and was 394.5 cfs, which is equivalent to an average of 782.4 acre feet per day or an average of 24,254 acre feet per month. The L-8 is primarily used for water supply. October 2013 was considered the third driest October on record for areas near West Palm Beach (LRWRP area). High outflows may have been a result of increased needs for water during dry conditions (Figure E.4- 1).

Presently, Lake Okeechobee itself is approximately 445,000 acres (Havens and Gawlik 2005). Given the relatively small volume of water being released from the C-10A culvert, on average, halting flows into the L-8 canal from Lake Okeechobee will not result in considerable increases in lake stage. This is not surprising considering the small size of the canal.

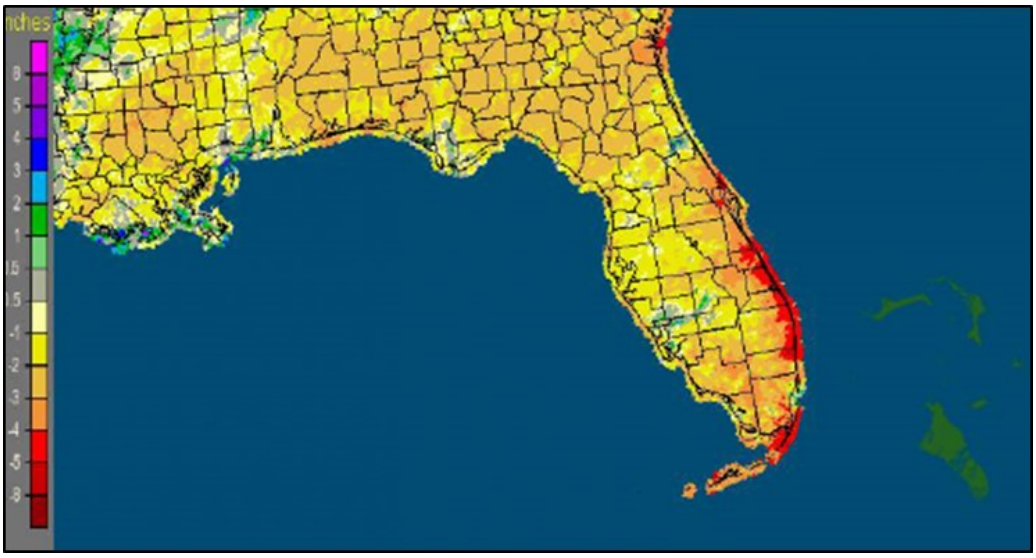


Figure E.4- 1: October 2013 Monthly Departure from Normal Precipitation (Griffin and Zierden 2013).

E.5.2 Summary and Conclusions

ALT10 is not expected to have significant impacts on Lake Okeechobee.

E.6 Overall Rankings of LRWRP Alternatives

The RECOVER Regional Evaluation Team (Table E.6- 1) reviewed the performance of the final array of alternatives for effects on the NWFLR (PM1), Loxahatchee Watershed (PM4), connectivity (PM9), and Lake Okeechobee lake stage (no PM). Conclusions concerning these effects can be found at the end of each related section above. Overall, regarding ecological and hydrological performance, the alternatives in the final array for the LRWRP were ranked on the basis that LRWRP restoration regarding the NWFLR (PM1) and the total Loxahatchee Watershed (PM4 + PM9) have equal weight (Table E.5- 1). All of the project alternatives improve performance when compared to the FWO. ALT5R was the best performing alternative, on average, of the final array for LRWRP from an ecological and hydrological perspective in meeting the goals and objectives of LRWRP.

Table E.5- 1: Overall Ranking of LRWRP Alternatives Based on Performance.

Metric	Ranking for ALT2	Ranking for ALT5R	Ranking for ALT10	Ranking for ALT13
NWFLR (PM1)	3	2	1	4
Total Watershed (PM4 + PM9)	3	2	4	1
AVG	3	2	2.5	2.5
Overall Ranking	**4**	**1**	**2.5**	**2.5**

*1 represents the best performing ALT while 4 represents the worst performing ALT.

E.7 RECOVER EVALUATION

E.7.1 RECOVER Regional Evaluation Team

Table E.6- 1: RECOVER Regional Evaluation Team

Member Name	Agency
Michael Simmons	USACE
Jenna May	USACE
Miles Meyer	USFWS
Phyllis Klarmann	SFWMD
Andy Rodusky	SFWMD

E.7.2 RECOVER Executive Committee Review

This RECOVER regional evaluation was reviewed by members of the RECOVER Executive Committee (REC) in Table E.6- 2.

Table E.6- 2: Members of the REC who reviewed this RECOVER Regional Evaluation.

REC Member	Agency
Gretchen Ehlinger	USACE
Fred Sklar	SFWMD
Agnes McLean	NPS
Laura Brandt	USFWS

E.8 REFERENCES

Cook, M. and M. Baranski. 2018. South Florida wading bird report. Technical Report. South Florida Water Management District, West Palm Beach, FL. 48 pp.

Fletcher, R., E. Robertson, B. Jeffery, C. Poli, and S. Dudek. 2018. Snail kite demography. 2018 Report. US Army Corps of Engineers, Jacksonville District. Jacksonville, Florida. 91 pp.

Griffin, M. and D. Zierden. 2013. Climate summary for Florida. Report. Florida Climate Center. Florida State University, Tallahassee, Florida.

Florida Natural Areas Inventory (FNAI). 2010. Guide to the natural communities of Florida: 2010 edition. Florida Natural Areas Inventory, Tallahassee, FL.

Frederick, P. C. and M. G. Spalding. 1994. Factors affecting reproductive success of wading birds (Ciconiiformes) in the Everglades ecosystem. Everglades: the ecosystem and its restoration: 659-691.

Frederick, P. C. and M. W. Collopy. 1989. Nesting success of five ciconiiform species in relation to water conditions in the Florida Everglades. Auk 106: 625-634.

Herring, H.K., and D. E. Gawlik. 2011. Resource selection function for wood stork foraging habitat in the southern Everglades. Waterbirds 34: 133-142.

Klassen, J. A., D. E. Gawlik, and P. C. Frederick. 2016. Linking wading bird prey selection to number of nests. The Journal of Wildlife Management 80(8):1450-1460.

McVoy, C. W., W. P. Said., J. Obeysekera, J. A. VanArman, and T. W. Dreschel. 2011. Landscapes and hydrology of the predrainage Everglades. University Press of Florida, Gainesville, FL: 342 pp.

Meyer, K, G. Kent, and A. Powell. 2018. Collaborative studies of snail kites and apple snails. Presentation for the Snail Kite Coordination Committee Meeting. Presented April 17, 2018.

National Research Council. 2015. Review of the Everglades aquifer storage and recovery regional study. Committee to Review the Florida Aquifer Storage and Recovery Regional Study Technical Data Report; Water Science and Technology Board, Division on Earth and Life Studies, National Research Council of the National Academies. The National Academies Press, Washington, D.C.

NOAA. n.d. Relative sea level trend 8722670 Lake Worth Pier. Retrieved from https://tidesandcurrents.noaa.gov/sltrends/sltrends_station.shtml?id=8722670.

Ogden, J. C., S. M. Davis, T. K. Barnes, K. J. Jacobs, and J. H. Gentile. 2005. Total system conceptual ecological model. Wetlands 25(4) 955-979.

Palm Beach County. 2016. A history of Palm Beach County inlets. Palm Beach County, FL. 16 pgs. Available at http://www.pbcgov.com.

RECOVER. 2002. Model uncertainty workshop report. U.S. Army Corps of Engineers, Jacksonville District, Jacksonville, FL, and South Florida Water Management District, West Palm Beach, FL. July 2002.

RECOVER. 2005. The RECOVER team's recommendations for interim goals and interim targets for the comprehensive Everglades restoration plan. U.S. Army Corps of Engineers, Jacksonville District, Jacksonville, FL, and South Florida Water Management District, West Palm Beach, FL. February 17, 2005.

Ridler, M.S., R. C. Dent, and D. A. Arrington. 2006. Effects of two hurricanes on *Syringodium filiforme*, manatee grass, within the Loxahatchee River Estuary, Southeast Florida. Estuaries and Coasts 29(6A) 1019-1025.

Strong, A. M., G. T. Bancroft, and S. D. Jewell. 1997. Hydrological constraints on tricolored heron and snowy egret resource use. Condor 99: 894-905.

SFWMD. 2010. Canals in South Florida: a technical support document. South Florida Water Management District, West Palm Beach, FL, April 2010.

SFWMD. 2015. Lainhart and Masten Dams maintenance repair project permitting report. South Florida Water Management District, West Palm Beach, FL. July 2015.

SFWMD. 2017. Model calibration update of the northern Palm Beach County version of the Lower East Coast subregional model (LECsR-NP) draft. South Florida Water Management District, West Palm Beach, FL. May 1, 2017.

SFWMD and FDEP. 2006. Restoration plan for the Northwest Fork of the Loxahatchee River. South Florida Water Management District, West Palm Beach, FL, April 2006.

SFWMD, FDEP FPS, LRD and LRIT. 2010. Loxahatchee River science plan. South Florida Water Management District, West Palm Beach, FL; Florida Department of Environmental Protection, Florida Park Service District 5, Hobe Sound, FL.

Trexler, J., and T. Robertson. 2006. Aquatic fauna and periphyton status data collection. Annual Report Contract CP040130 to South Florida Water Management District, 3301 Gun Club Road, West Palm Beach, FL 33406, 10 October 2006: 54pp.

Trexler, J. and C. Goss. 2009. Aquatic fauna as indicators for Everglades restoration: Applying dynamic targets in assessments. Ecological Indicators Special issue 9(6S): S108-S119.

USACE and SFWMD. 2015. Loxahatchee River Watershed restoration project performance measure 1: seasonal flows to manage salinity and floodplain hydroperiod in the Northwest Fork of the Loxahatchee River. U.S. Army Corps of Engineers, Jacksonville District, Jacksonville, FL, and South Florida Water Management District, West Palm Beach, FL. April 29, 2015.

USFWS. 1985. Recovery plan for the red-cockaded woodpecker. Report. US Fish and Wildlife Service, Southeast Region. Atlanta, Georgia 316 pp.

VanArman, J., G. Graves, and D. Fike. 2005. Loxahatchee Watershed conceptual ecological model. Wetlands 25(4): 926-942.

E.9 SUPPLEMENTAL INFORMATION

E.9.1 Dry Season Scoring Maps for VEC Zones (excluding Riverine Flood Plain)

Dry season score (or percentage of time meet the criteria) for five VEC zones: Tidal Flood Plain (Figure E.8-1), Vallisneria (Figure E.8- 2), Oligohaline (Figure E.8- 3), Mesohaline (Figure E.8- 4), and Polyhaline (Figure E.8- 5) for ECB (top left), FWO (top right), ALT2 (mid left), ALT5 (mid right), ALT10 (bottom left), and ALT13 (bottom right).

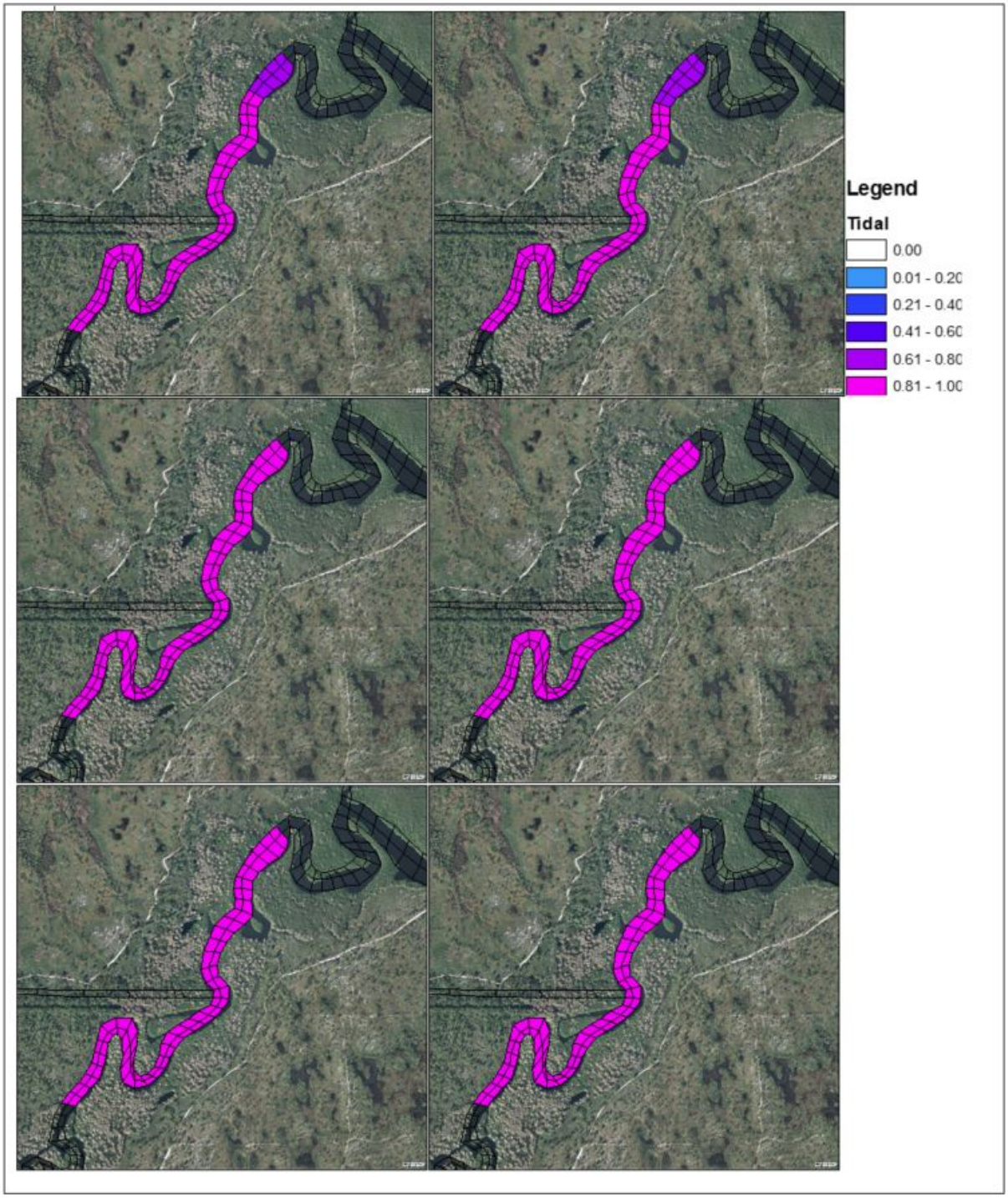


Figure E.8- 1: Map of Dry Season Scoring of LRWRP Alternatives in the Tidal Flood Plain VEC.

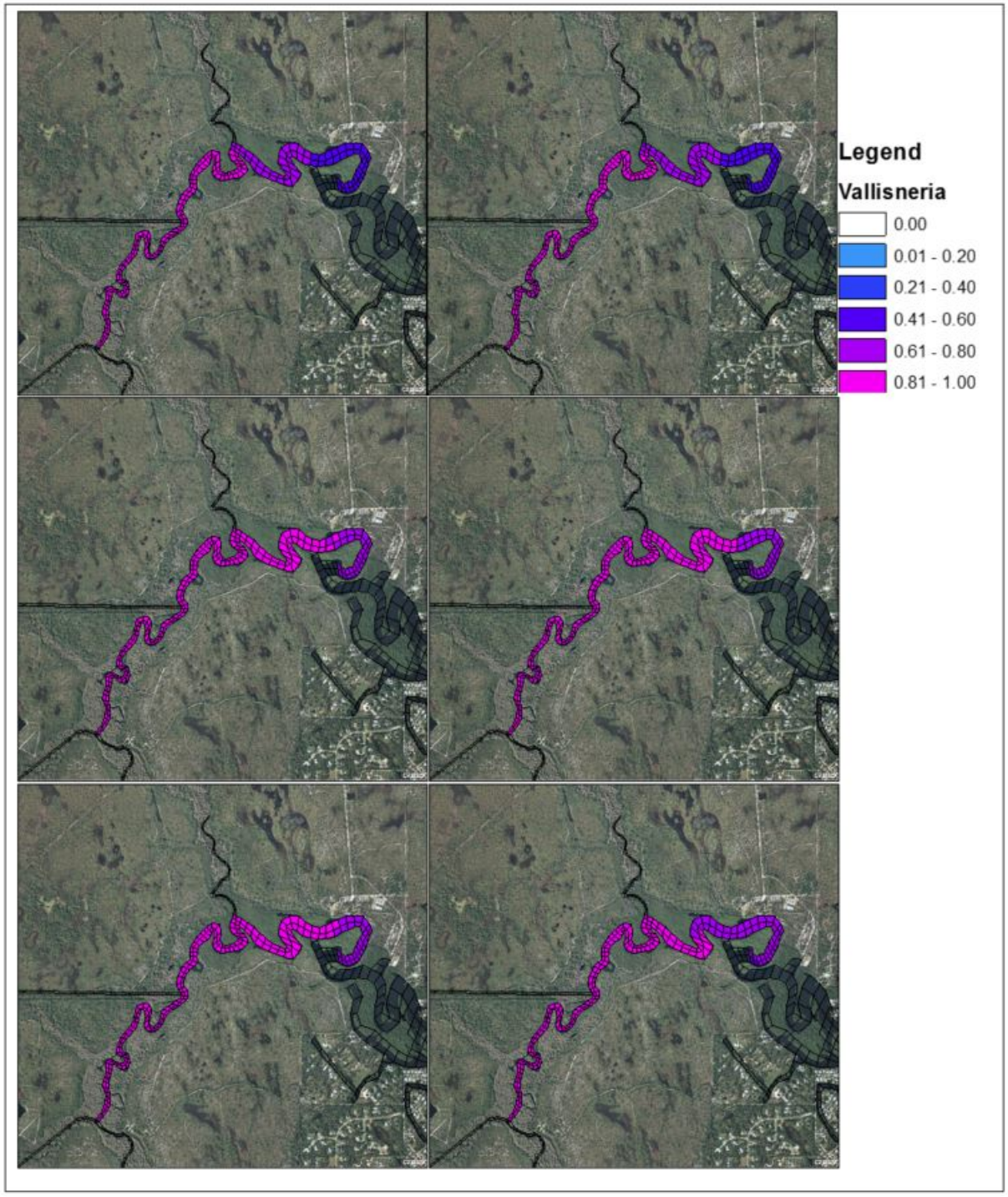


Figure E.8- 2: Map of Dry Season Scoring for LRWRP Alternatives for the Vallisneria VEC.

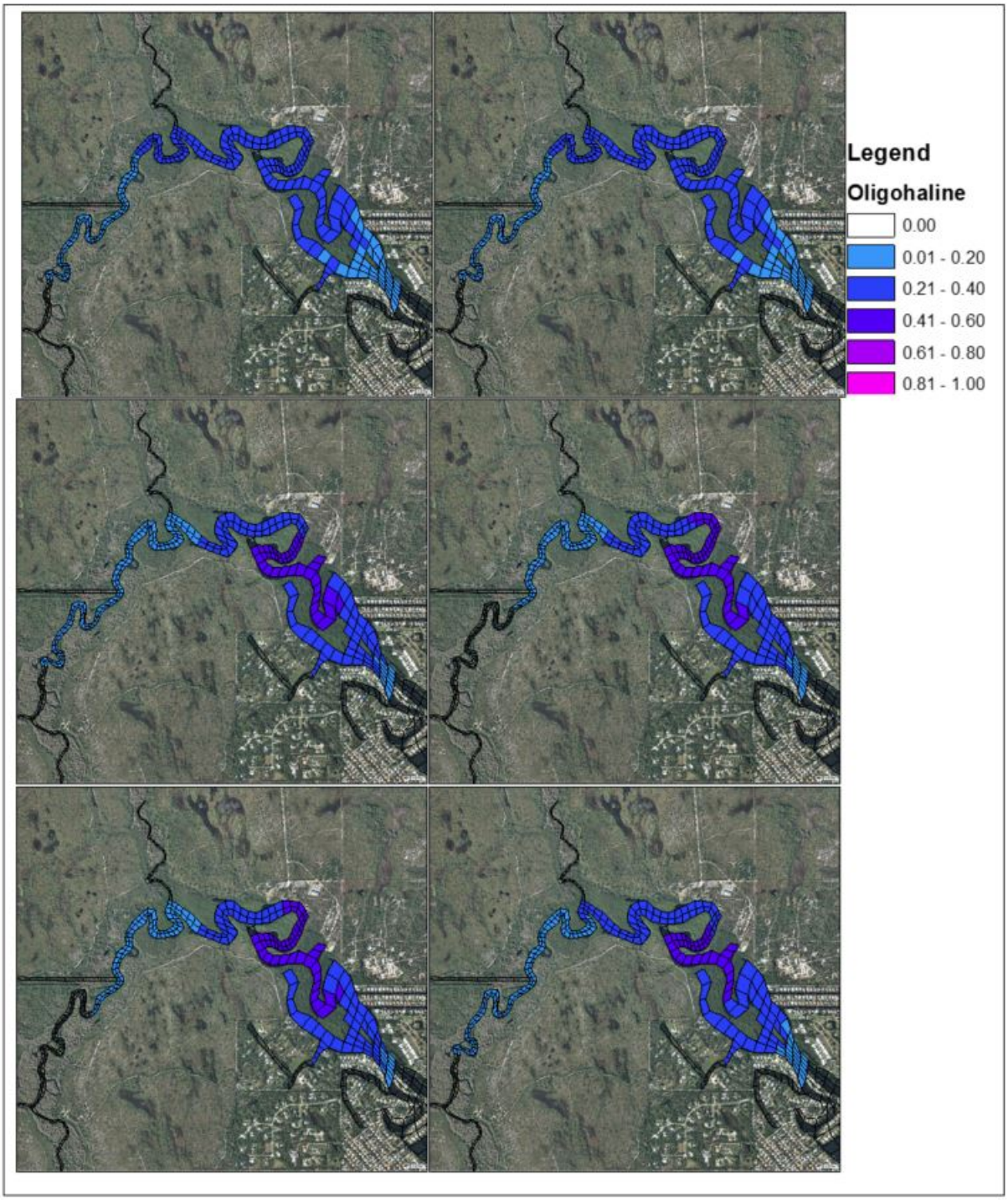


Figure E.8- 3: Map of Dry Season Scoring for the Oligohaline Zone VEC.

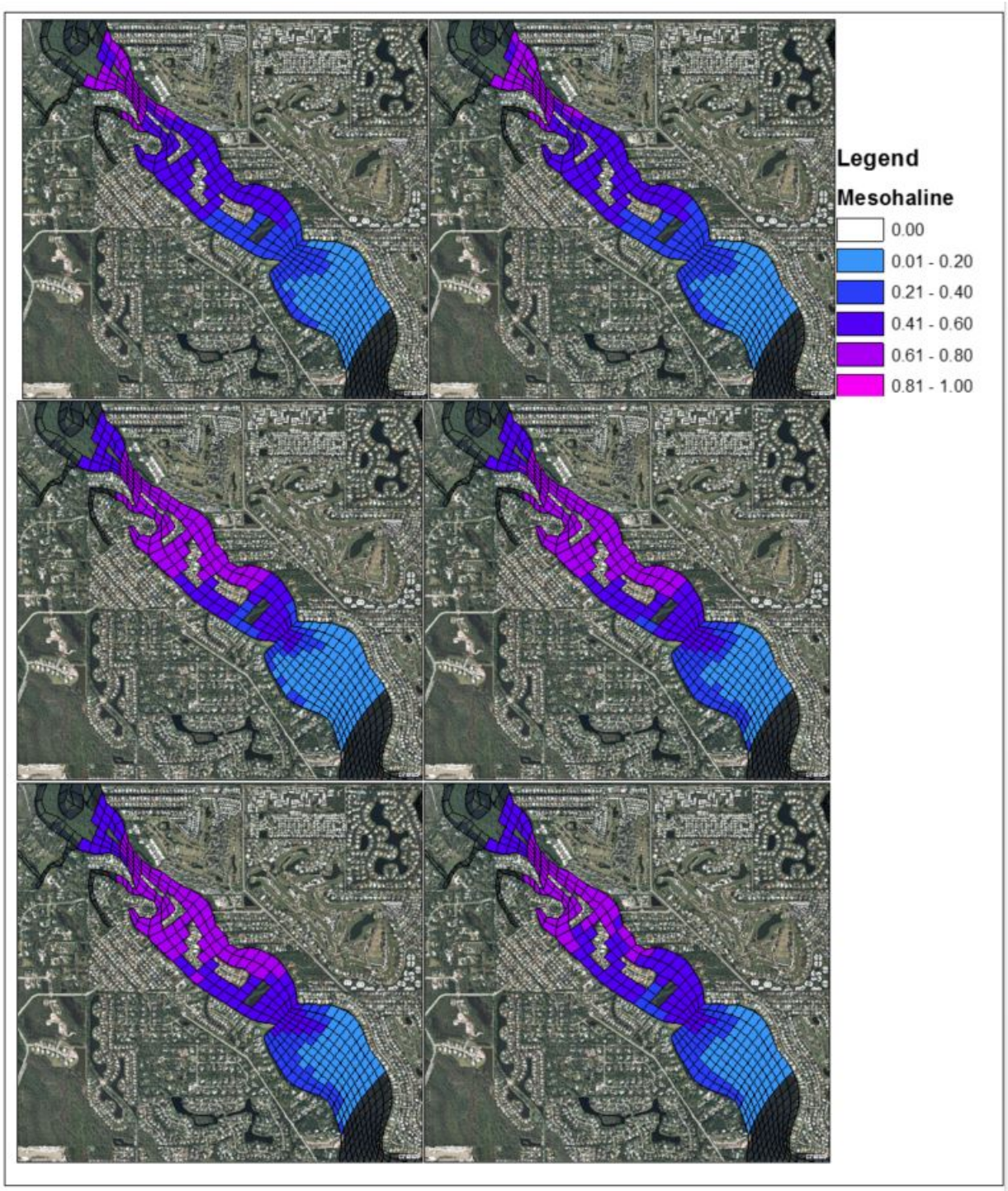


Figure E.8- 4: Map of Dry Season Scoring for the Mesohaline Zone VEC.

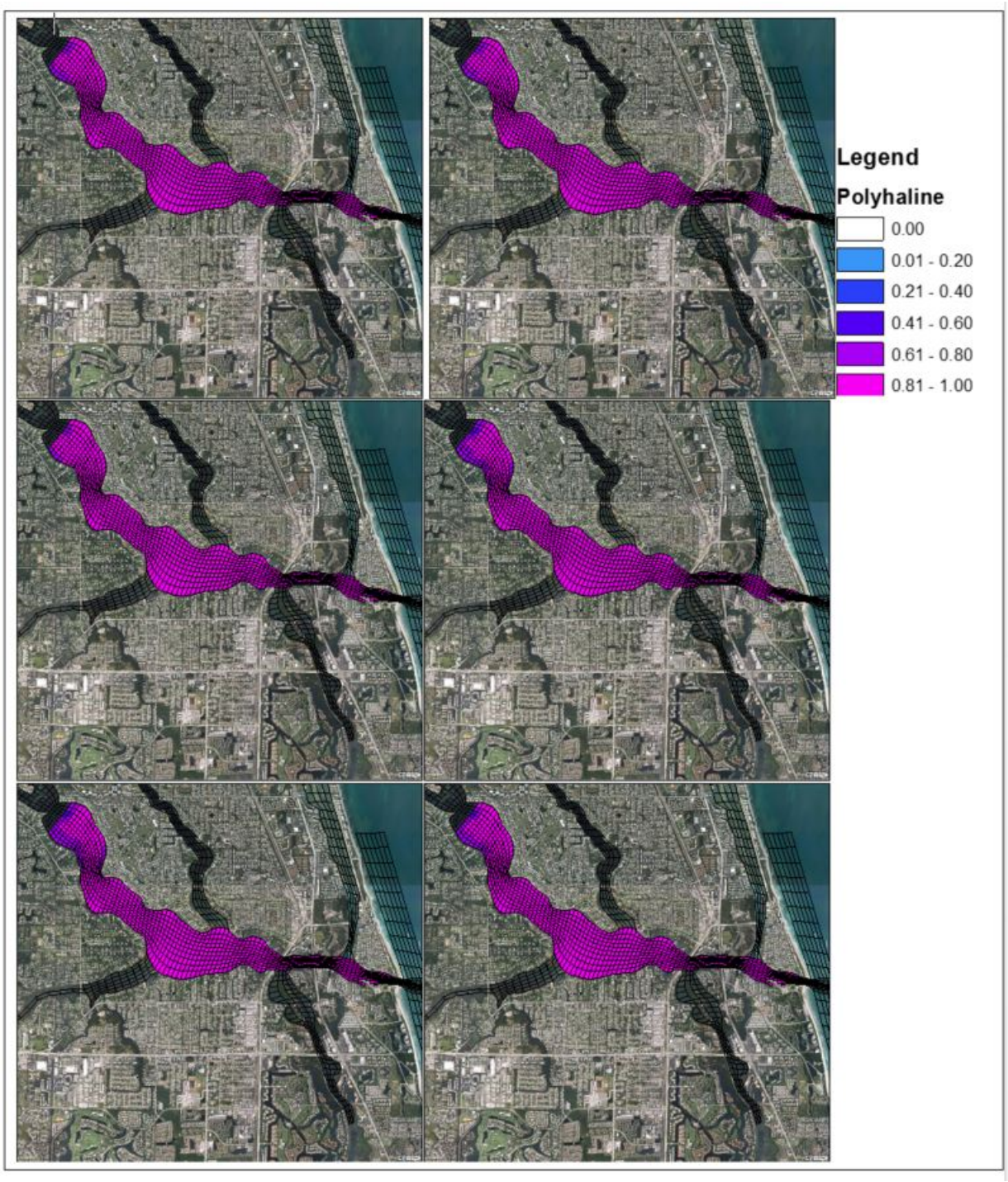


Figure E.8- 5: Map of Dry Season Scoring for the Polyhaline Zone VEC.

Wet Season Scoring Maps for VEC Zones (Excluding Riverine Flood Plain)

Wet season score (or percentage of time meet the criteria) for five VEC zones: Tidal Flood Plain (Figure E.8- 6), Vallisneria (Figure E.8- 7), Oligohaline (Figure E.8- 8), Mesohaline (Figure E.8- 9), and Polyhaline

(Figure E.8- 10) for ECB (top left), FWO (top right), ALT2 (mid left), ALT5 (mid right), ALT10 (bottom left), and ALT13 (bottom right).

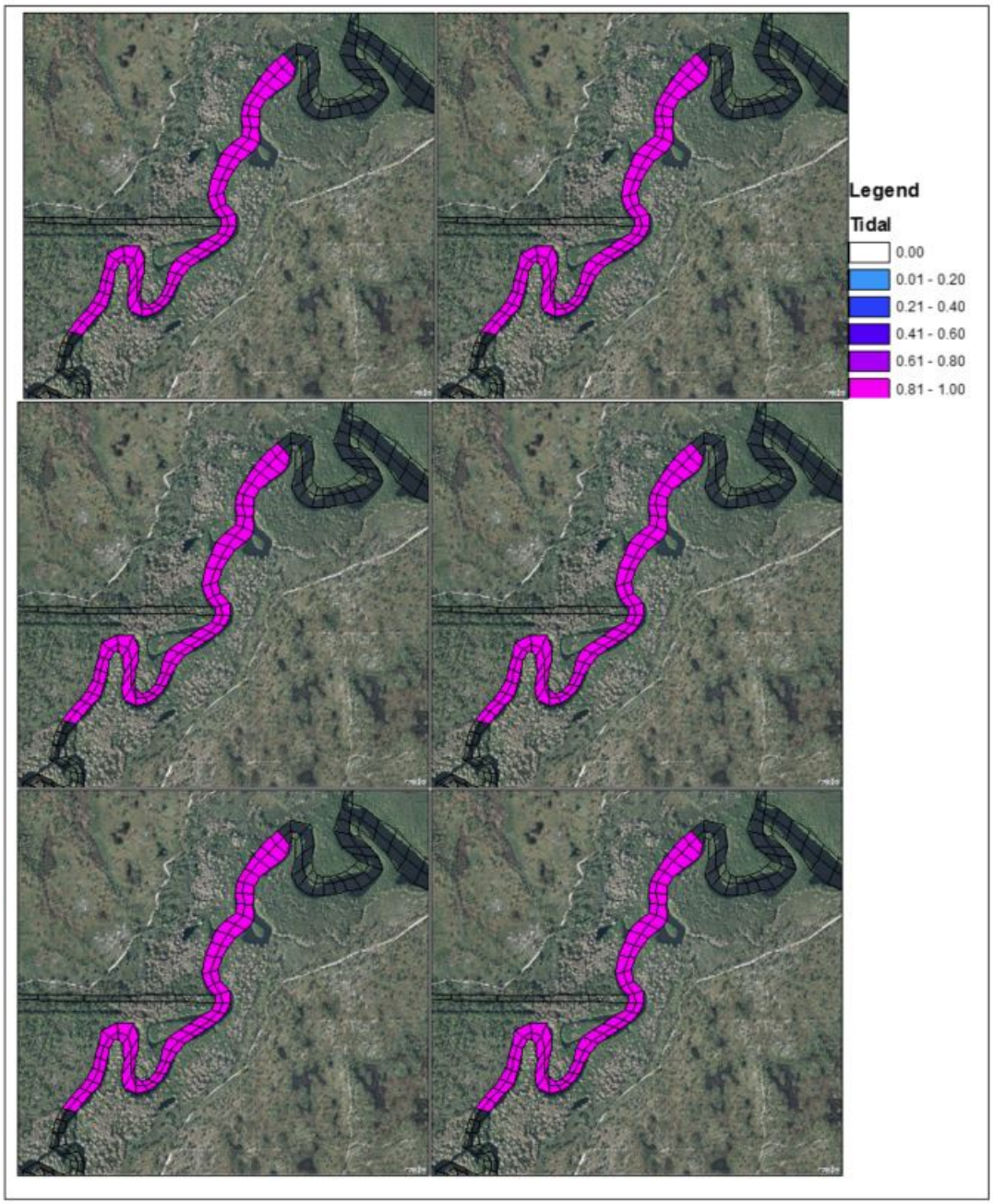


Figure E.8- 6: Map of Wet Season Scoring for the Tidal Flood Plain VEC.

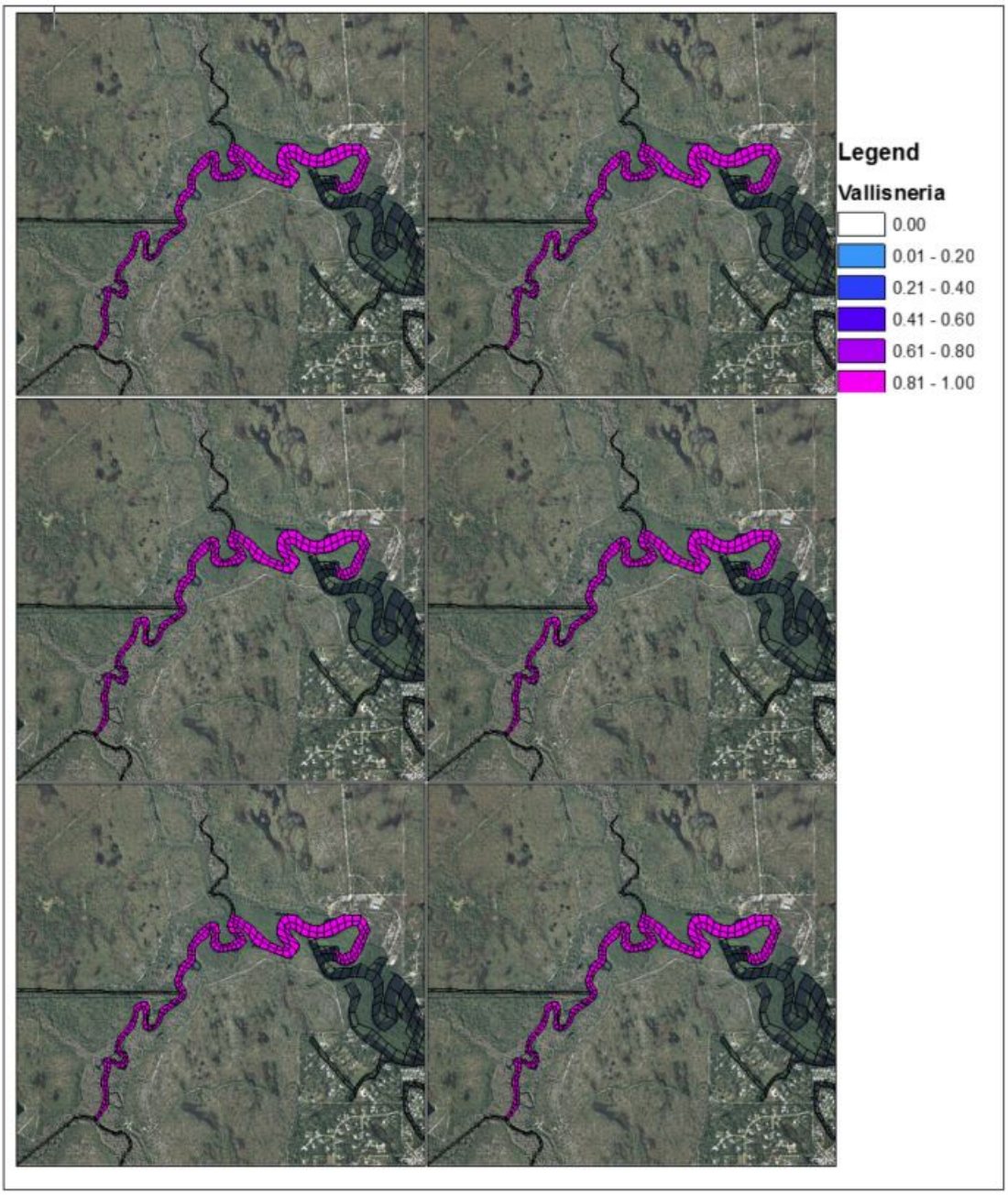


Figure E.8- 7: Map of Wet Season Scoring for the Vallisneria VEC.

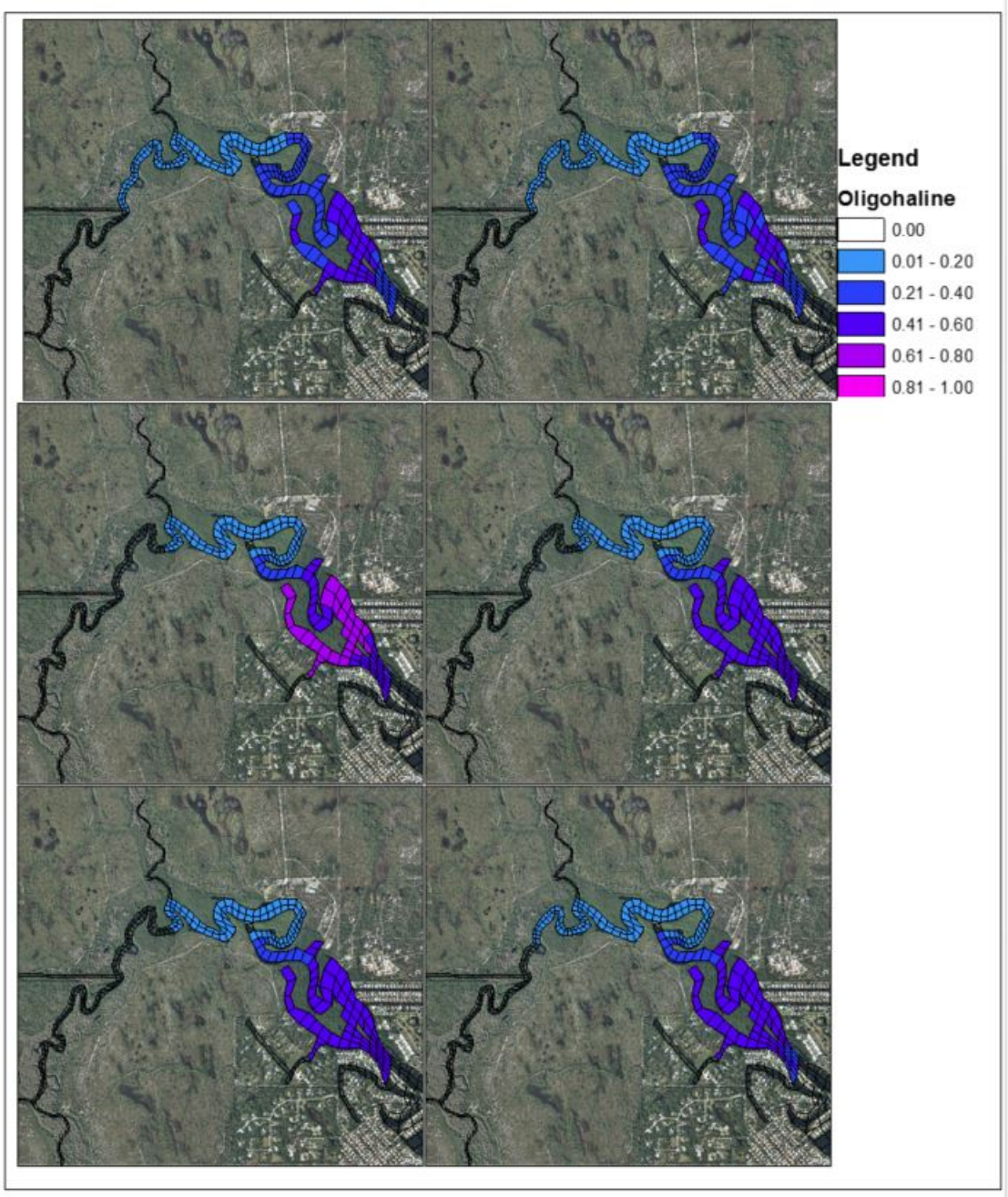


Figure E.8- 8: Map of Wet Season Scoring for the Oligohaline Zone VEC.

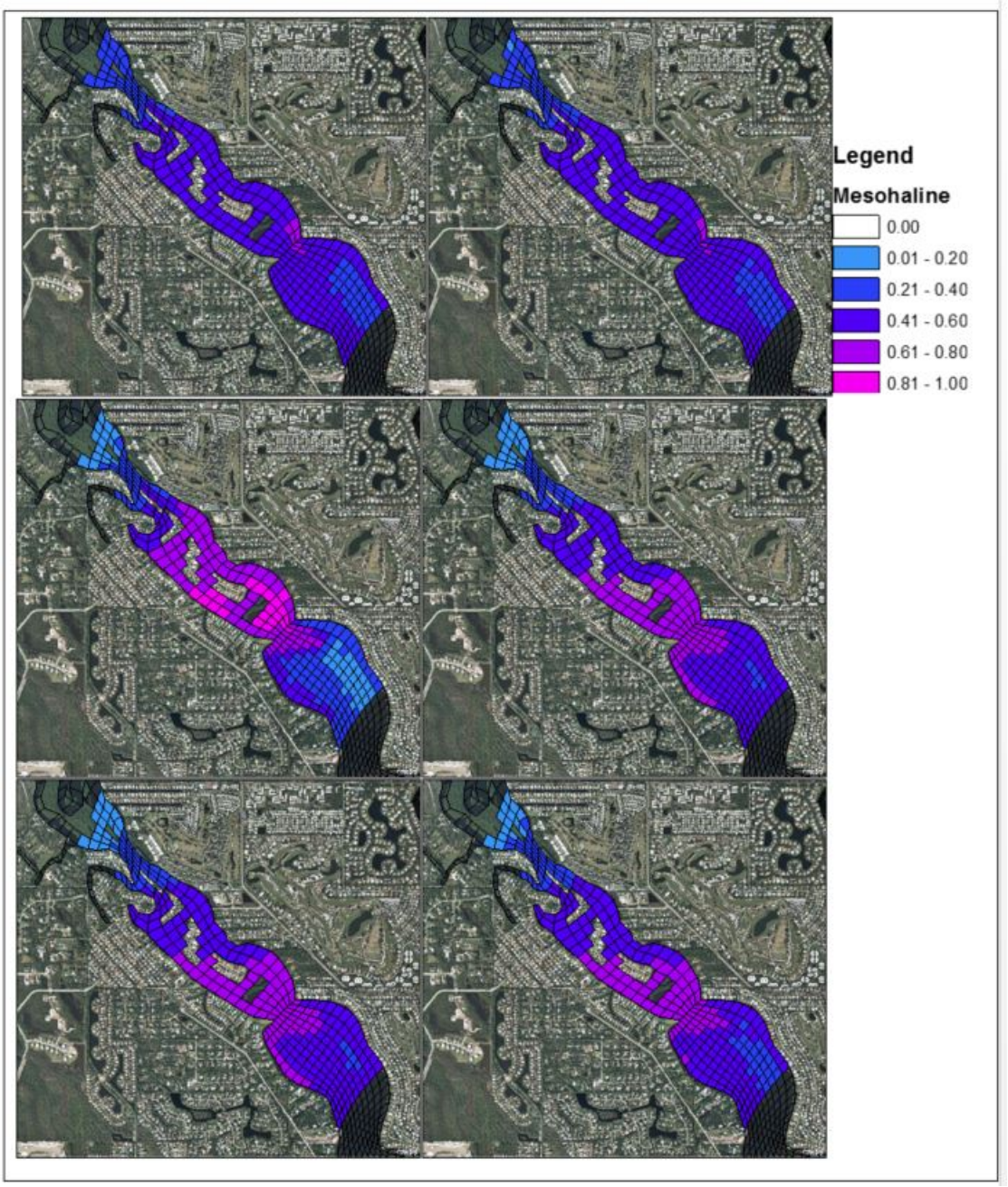


Figure E.8- 9: Map of Wet Season Scoring for the Mesohaline Zone VEC.

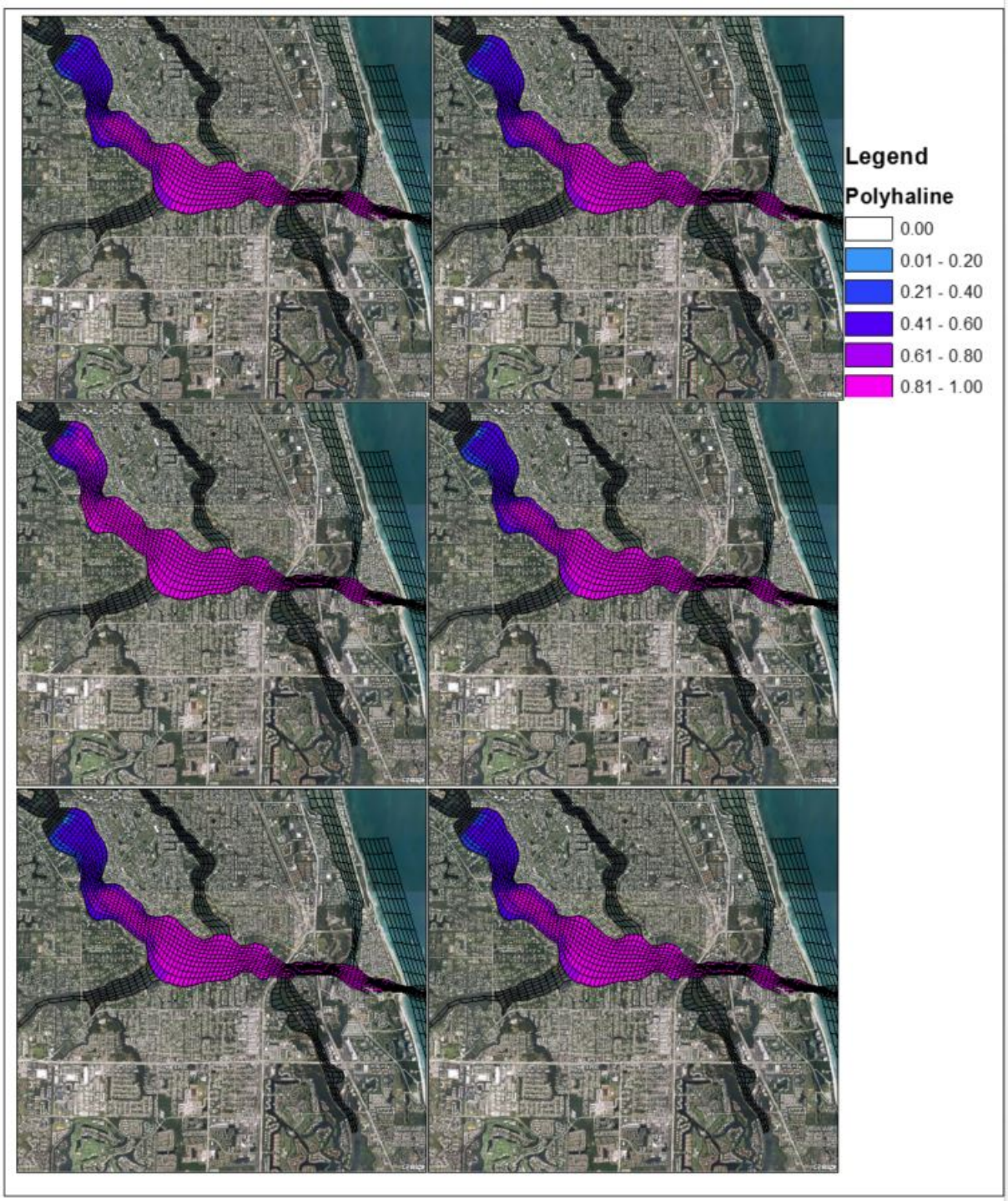


Figure E.8- 10: Map of Wet Season Scoring for the Polyhaline Zone VEC.

E.10 RECOVER CONSISTENCY REVIEW: LRWRP PROJECT GOALS AND OBJECTIVES AND PERFORMANCE MEASURES

E.10.1 RECOVER Consistency Review

Loxahatchee River Watershed Restoration Project (LRWRP)

RECOVER Consistency Review of Project Goals and Objectives and Performance Measures

Reviewers: Peter Doering, SFWMD, Tom Dreschel, SFWMD, Gretchen Ehlinger, USACE, Amanda McDonald, SFWMD, Agnes McLean, NPS, Steve Traxler, FWS

Coordinator: Kelly Keefe, USACE

Date: May 15, 2015

Introduction

The following document summarizes a few members of the RECOVER review of LRWRP project goals and objectives and performance measures as they related to CERP goals and objectives and RECOVER system-wide/regional performance measures. The review was conducted using the following documents:

1. LRWRP Report Synopsis (includes goals and objectives and background on project)
2. Performance Measure 1 - Northwest Fork Salinity
3. Performance Measure 4 - Plant Community Hydrology
4. Performance measure 9 - Connectivity
5. LRWRP Virtual Tour Presentation and Project Delivery Team PM presentation

General Comments

<u>Goals and Objectives Consistency</u>

1. LRWRP goals and objectives are consistent with CERP goals and objectives described in the yellow-book Table E.2-3-1. The overall goal of LRWRP is to restore and sustain the overall quantity, quality, timing, and distribution of freshwaters to the federally designated "National Wild and Scenic" Northwest Fork of the Loxahatchee River (NWFLR) for current and future generations. This project also seeks to restore, sustain, and reconnect the area's wetlands and watersheds that form the historic headwaters for the river and flows and salinity conditions in the Loxahatchee River Estuary. While the LRWRP Objectives are clearly listed, a crosswalk table with the CERP Goals and Objectives would be useful. The table below is our attempt at that table.

Table E10-1. Yellow Book Goals and Objectives.

Yellow-Book Goal and Objective	LRWRP Objective
Enhance Ecological Values - Increase the total spatial extent of natural areas	Objective 3: Increase natural area extent of wetlands
Enhance Ecological Values - Improve habitat and functional quality	Objective 1: Restore wet and dry season flows of water to the National Wild and Scenic Northwest Fork of the Loxahatchee River and the river floodplain Objective 4: Restore connections between Corbett Wildlife Management Area, Pal-Mar/Cypress Creek basin, Loxahatchee Slough, Grass Waters Preserve and Loxahatchee River to improve hydrology, sheetflow, hydroperiods, natural storage, and vegetation communities
Enhance Ecological Values - Improve native plant and animal species abundance and diversity	Objective 2: Restore oysters, seagrass and other estuarine communities in the Loxahatchee River Estuary by reducing excess wet season high flows to Loxahatchee River Estuary through South Fork at the coastal control structure S-46 Objective 5: Restore native plant and animal species abundance and diversity in Loxahatchee River watershed natural areas, river, and estuary
Enhance Economic Values and Social Well Being - Increase availability of fresh water (agricultural/municipal & industrial)	Objective 7: Increase availability of water supply
Enhance Economic Values and Social Well Being - Reduce flood damages (agricultural/urban)	No corresponding LRWRP objective
Enhance Economic Values and Social Well Being - Provide recreational and navigation opportunities	Objective 6: Provide recreational opportunities
Enhance Economic Values and Social Well Being - Protect cultural and archeological resources and values	No corresponding LRWRP objective

2. LRWRP planning objective 2 states that estuary salinity benefits will be measured based on the percent reduction in frequency and duration of S-46 structure peak flow discharges that relate to salinity threshold criteria for seagrasses. Are the threshold discharges going to be compared to oyster

thresholds as well? The actual objective lists oysters, seagrass and other estuarine communities and PM1 uses tape grass, fish larvae, oysters and seagrass to calculate benefits.

3. Section 10: In the hydrology section it states that the primary focuses of the LRWRP project are the Loxahatchee River and the LWL watersheds. Where are the PMs for LWL?

4. The report seems organized according to a prescribed format and this makes it hard to follow at times and also seems to have caused considerable redundancy. For example, problems associated with altered hydrology are summarized in slightly different ways on pages 5 (under Section 5), 11 (under Section 6.2 project area) 14, and 15 (under section 8.1 Hydrological/ Ecological Problems).

5. There should be more explicit emphasis on restoration of flows (hydroperiod/depth) to the floodplain of the Loxahatchee River. This goal is really not explicitly stated until page 17 of the report. "Restore wet and dry season flows of water to the National Wild and Scenic Northwest Fork of the Loxahatchee River and the river floodplain. " The restoration goal of floodplain hydroperiod should be identified early on in the report. This is particularly important as the floodplain inundation targets established in the Restoration Plan for the Northwest Fork of the Loxahatchee River is the metric used to measure restoration.

6. Is Lake Worth Lagoon included in this study? On page 21 the report states that the primary focuses of the LRWRP project are the Loxahatchee and Lake Worth Lagoon watersheds. Yet the primary goal is to restore freshwater flow to the "National Wild and Scenic" Northwest Fork of the Loxahatchee River (see page 16).

Performance Measure Consistency

Performance Measure #1 – Seasonal Flows to Manage Salinity and Floodplain Hydroperiod in the Northwest Fork of the Loxahatchee River

Justification Section:

1. This section is confusing. What is supposed to be justified here? Is it the LRWRP itself, the VEC or the flow target from the Restoration Plan?

2. Suggest that this section reiterate the goals of the LRWRP as stated in the project synopsis report, identify which goal (s) this PM addresses and concentrate on why the VEC, salinity envelopes and flow targets are appropriate for measuring progress towards these goals.

3. Paragraph 2 on page 2 needs a bit of rewording. In its present form it seems to indicate that opening of the inlet was a structural alteration that lead to reduced freshwater inflow. One approach would be to re-write the paragraph to emphasize how structural alterations have led to saltwater intrusion.

4. On pages 2 and 3, the discussion of the VECs, their location and their salinity envelopes could be improved by providing a more detailed description of how they were chosen and the relationships between location, salinity and the target flow scenario. For example, were the locations of the VEC

chosen because this is where the flow target produced favorable salinity or does this reflect their present distribution in the river estuary?

CERP Evaluation Target

1. The preferred restoration flow scenarios describe the LV90TV60, but later compare it to LV90TV90 and LV90TV120. The later scenarios are not explained and are very confusing. Suggest that a table that explains the scenarios be added or an explanation of the scenarios added. Include the table from the Restoration Plan since it is a key factor in the performance measure. The Floodplain Targets reference Figure E.2-2 for LV90TV60, but there is no Figure E.2-2 in the PM doc sheet.

2. Page 10: The document states that a conservative target of 1 psu was set in the Restoration plan for the freshwater tidal community upstream of RM 8.2. In Table E.1-1 the target for the Upper Tidal Flood Plain is <2 psu. Why the difference? Are these two criteria considered compatible?

Evaluation Protocol

1. The target locations given in Table E.1-1 do not entirely correspond to the locations given in the list of VECs in the Justification section.

2. Locations of VEC overlap. This not necessarily a problem but it might affect scoring in some unforeseen way.

3. The protocol used to score the Riverine Floodplain VEC is pretty straight forward. However, as formulated the procedure might not be sensitive enough to distinguish between alternatives. For the two areas in the example given on page 11, an alternative that produced 5 months and 2 months of inundation would also yield 328 habitat units. It might be better to have a more defined target inundation period of say 6 months. Anything with at least 6 months of inundation gets a 1. Five months gets (5/6=) 0.83, 4 months gets (4/6=) 0.66 etc.

4. Riverine Floodplain: Is there an upper limit to inundation period. Would, for example, 10 months be too long and hence detrimental. Should a scoring protocol be developed for this eventuality?

5. Other VECs: No example is given. However, the scoring of habitat units for these would be likely based on the some measure of time that the salinity is within the preferred range at the preferred location(s). Compute mean monthly salinity in each 1 km segment from RM0 to RM16 for the period of record. Establish a target number of months each year that salinity should be in the preferred range for each VEC. For *Vallisneria* this would be 12 months each year. For fish larvae it may be only each month from March-June. For each segment within the spatial range of a VEC, compute the number of months during the relevant time of year that salinity is within the preferred range. For each segment, divide the observed number of months by the target number of months with the desired salinity range and multiply by the number of acres in the segment. Sum acres across segments within the desired spatial range for each VEC to calculate habitat units.

6. How do you score the salinity targets? If the salinity is out of the range for the entire POR then it would score a 0, if it is in the range for the entire POR then it would score a 1. How does it score for being in range for part of the POR? Is it always 0.5 if it is one day less the than target?

7. It looks like the actual goal is to restore flows at Lainhart Dam and the salinity targets are based on flows. I would try to state that clearly at the start of the PM doc sheet, since flows are really the only thing the project is going to affect. Flows are the target, salinities result from the flows and the targets are based on salinities of the VECs.

8. Please give an example using one of the VECs, not just the riverine floodplain example. The VECs use the other models and are not just based on output from the hydrological model.

9. Scoring system is not very sensitive, 1 month and 5 month meeting of the salinity score the same (0.5). There is a big ecological difference between meeting the target 1% of the time versus 99% of the time, but as it is written, both would receive a score of 0.5. There needs to be greater sensitivity in the scoring rubric.

Performance Measure #4 – Hydrologic Regimes of Major Plant Communities in the Loxahatchee Watershed and Adjacent Wetlands

Justification Section:

1. The document states that a separate performance measure has been established for Grassy Waters Preserve. Is that performance measure being used for this project? Where is that PM doc sheet?

Evaluation Protocol

1. When were the WRAP assessments completed? It reads as if they were done in 2004. If they are being used for the evaluation, should they be updated to assess current conditions?

2. Using the WRAP from 2004 makes the assumption that the 2004 assessment is the existing condition. If this is the case, this needs to be explained in the document.

Performance Measure #9- Hydrologic/Spatial Connectivity

CERP Evaluation Target

1. The target is the highest % increase in connectivity. What is the CERP target? 100%, 90%, what are we shooting for? I can see evaluating and comparing the alternatives based on the highest % connectivity, but what is the end goal? What are we ultimately trying to achieve?

Evaluation Protocol

1. There is currently some connection to the NW Fork of the Loxahatchee, how would it score using your criterion rubric?

2. If Existing condition is considered a zero, is future without project considered a zero as well? Could connectivity get worse than it is now?

3. Scoring system is not very sensitive, partial connectivity always scores a 12.5. There is a big ecological difference between a 1% connectivity and a 99% connectivity, but as it is written, both would receive a score of 12.5. There needs to be greater sensitivity in the scoring rubric.

4. How is this PM used to calculate habitat units? You get a score from the criterion rubric, but what is done with it from there?

E.10.2 LRWRP Eco-subteam Response to RECOVER Consistency Review

Loxahatchee River Watershed Restoration Project (LRWRP) Ecosubteam Response to Comments from:

RECOVER Consistency Review of Project Goals and Objectives and Performance Measures
Ecosubteam Responders: Andy LoSchiavo, Patti Gorman

Date: June 4, 2015

Introduction

The following document summarizes the LRWRP ecosubteam responses to RECOVER comments on the LRWRP project goals and objectives and performance measures. A subset of the full ecosubteam reviewed the comments and provided responses to address comments and suggestions to improve the statements of LRWRP goals and objectives and how they will be measured with the performance measures. The ecosubteam appreciates this independent review by Everglades science experts and believe the updates that will be made to performance measure documentation will improve their validity and clarity to a variety of audiences. We have responded to comments by providing a name and response after each comment provided using the original RECOVER response document format.

Review Comments and LRWRP Ecosubteam Responses

<u>Review Part 1 and 2: Goals and Objectives Consistency with CERP</u>

1. LRWRP goals and objectives are consistent with CERP goals and objectives described in the yellow-book table 5-1. The overall goal of LRWRP is to restore and sustain the overall quantity, quality, timing, and distribution of freshwaters to the federally designated "National Wild and Scenic" Northwest Fork of the Loxahatchee River (NWFLR) for current and future generations. This project also seeks to restore, sustain, and reconnect the area's wetlands and watersheds that form the historic headwaters for the river and flows and salinity conditions in the Loxahatchee River Estuary. While the LRWRP Objectives are clearly listed, a crosswalk table with the CERP Goals and Objectives would be useful. The table below is our attempt at that table.

Table E10-2. Yellow Book Goals and Objectives Consistency with LRWRP Objectives.

Yellow-Book Goal and Objective	LRWRP Objective
Enhance Ecological Values - Increase the total spatial extent of natural areas	Objective 3: Increase natural area extent of wetlands
Enhance Ecological Values - Improve habitat and functional quality	Objective 1: Restore wet and dry season flows of water to the National Wild and Scenic Northwest Fork of the Loxahatchee River and the river floodplain. Objective 4: Restore connections between Corbett Wildlife Management Area, Pal-Mar/Cypress Creek basin, Loxahatchee Slough, Grass Waters Preserve and Loxahatchee River to improve hydrology, sheetflow, hydroperiods, natural storage, and vegetation communities
Enhance Ecological Values - Improve native plant and animal species abundance and diversity	Objective 2: Restore oysters, seagrass and other estuarine communities in the Loxahatchee River Estuary through South Fork at the coastal structure S-46. Objective 5: Restore native plant and animal species abundance and diversity in Loxahatchee River watershed natural areas, river, and estuary
Enhance Economic Values and Social Well Being - Increase availability of fresh water (agricultural/municipal & industrial)	Objective 7: Increase availability of water supply
Enhance Economic Values and Social Well Being - Reduce flood damages (agricultural/urban)	No corresponding LRWRP objective
Enhance Economic Values and Social Well Being - Provide recreational and navigation opportunities	Objective 6: Provide recreational opportunities
Enhance Economic Values and Social Well Being - Protect cultural and archeological resources and values	No corresponding LRWRP objective

Subteam Leads: Andy LoSchiavo and Patti Gorman

Response: We will include a cross walk table of LRWRP and CERP goals and objectives in future updates to the report synopsis which will become a draft project implementation report (PIR) and environmental impact statement (EIS).

Status: Resolved upon revisions to the document.

2. LRWRP planning objective 2 states that estuary salinity benefits will be measured based on the percent reduction in frequency and duration of S-46 structure peak flow discharges that relate to salinity threshold criteria for seagrasses. Are the threshold discharges going to be compared to oyster thresholds as well? The actual objective lists oysters, seagrass and other estuarine communities and PM1 uses tape grass, fish larvae, oysters and seagrass to calculate benefits.

Response: The changes in flows to the estuary from all sources (e.g., Lainhart dam, S-46, and tributaries) provided by the array of alternatives will be input into a salinity regression tool. This tool will provide an estimate of salinity envelops for the Entire River and estuary from Lainhart dam to the inlet. The effects on the estuarine indicators described in PM1 will then be evaluated for each alternative as well as the FWO and ECB in order to determine the lift provided by a given plan. The areas of improved habitat will then be turned into habitat units (HUs) by multiplying by the acreage of improvements along the river/estuary gradient. The LRWRP team will make sure the report language is up to date and consistent with current project expectations. Subteam Leads: Patti Gorman and Andy LoSchiavo

Status: Resolved on agreement to make sure the report language is up to date and consistent with current project expectations.

3. Section 10: In the hydrology section it states that the primary focuses of the LRWRP project are the Loxahatchee River and the LWL watersheds. Where are the PMs for LWL? Also in section 10: there is a statement that "Based on assumptions used for future forecasting, there is little reason to believe that hydrologic conditions in the LRWRP would be substantially different between 2050 and 2072". Given the current rate and projected rate of SLR, can this statement be supported? Are there any projections as to whether/how much restoration of the cypress regions could be expected with improved freshwater flows?

Response: Lake Worth Lagoon (LWL): Unlike NPB Part 1 this projects focus is on the NW Fork and the contributing watersheds including C-18, but is not formulated to achieve benefits in LWL. Therefore there are no LWL PMs this time. The watersheds and sub-basins are highly managed. Water that would route to the LWL can also be diverted towards the Loxahatchee River through flow-way 1 going through Grassy Waters Preserve.

Sea-Level Rise (SLR): The project will analyze sea-level rise effects on restoration benefits. At this time we have not yet done an analysis of much benefits that project will achieve vs. how much will be lost due to SLR. The planning assumption is that SLR in 22 years on the low and medium SLR curves will not be greater than 4-6 inches, and will not be a significant impact on restoration benefit lift compared to the future without project. SLR effects will not be large in the years specified in the planning of the project. SLR analysis will be done. Ecosubteam believes they do not need to adjust formulation based on this. Subteam Leads: Andy LoSchiavo and Patti Gorman

Status: Resolved on agreement to make changes and clarifications in the report.

4. The report seems organized according to a prescribed format and this makes it hard to follow at times and also seems to have caused considerable redundancy. For example, problems associated with altered hydrology are summarized in slightly different ways on pages 5 (under Section 5), 11 (under Section 6.2 project area) 14, and 15 (under section 8.1 Hydrological/ Ecological Problems).

Response: All new and rescoped USACE civil works projects must first develop a report synopsis that follows a standard template. Pg. 5 is as statement of Federal Interest that is intended to be short and concise (high level). Section 6.2 gives the reader more insight into each area of the project, whereas section 8.1 is a more detailed description of problems and opportunities to be addressed by the project. Subteam Leads: Andy LoSchiavo and Patti Gorman

Status: Resolved

5. There should be more explicit emphasis on restoration of flows (hydroperiod/depth) to the floodplain of the Loxahatchee River. This goal is really not explicitly stated until page 17 of the report. "Restore wet and dry season flows of water to the National Wild and Scenic Northwest Fork of the Loxahatchee River and the river floodplain. "The restoration goal of floodplain hydroperiod should be identified early on in the report. This is particularly important as the floodplain inundation targets established in the Restoration Plan for the Northwest Fork of the Loxahatchee River is the metric used to measure restoration.

Response: Agree, there is a lot of information from the 2006 and 2011 NW Fork Restoration Plans that can be used and/or referenced, as discussed on pg. 13, bullet 6. We will update the report to ensure restoration of floodplain hydroperiods is captured in the project background, existing and future conditions, and statement of problems and objectives. Subteam Leads: Patti Gorman and Andy LoSchiavo

Status: Resolved upon revisions to the document.

6. Is Lake Worth Lagoon included in this study? On page 21 the report states that the primary focuses of the LRWRP project are the Loxahatchee and Lake Worth Lagoon watersheds. Yet the primary goal is to restore freshwater flow to the "National Wild and Scenic" Northwest Fork of the Loxahatchee River (see page 16).

Response: No LWL is not included. The watersheds and subbasins are highly managed. Water that would route to the LWL can also be diverted towards the Loxahatchee River through flow-way 1 going through Grassy Waters Preserve. Understanding the three watersheds is necessary to understanding opportunities for bringing additional flow to restore the Loxahatchee River. Prior North Palm Beach County Part 1 planning efforts indicated that the Lake Worth Lagoon should be a separate CERP project. Subteam Leads: Andy LoSchiavo and Patti Gorman

Status: Resolved upon revisions to the document.

7. How to combine the evaluation protocols of the 3 PMs is not defined. This will probably be completed at a later date, but the earlier this process can be reviewed the better. Developing a measureable evaluation protocol that is sensitive to the alternatives has proven to be difficult in CERP.

Response: We are still developing the evaluation protocol of how the 3 PMs will be combined. We will be leveraging similar approaches used for Biscayne Bay Coastal Wetlands and Indian River Lagoon-South. The goal is to ensure that the smaller acreage restoration benefit lift in the Loxahatchee River freshwater floodplain, tidal floodplain, oligohaline, mesohaline, and estuarine areas are not valued less than the larger acreage upstream watershed. This RECOVER review was focused on the performance measures that will be used and not the habitat units methodology, which is a separate project task.

Subteam Leads: Andy LoSchiavo and Patti Gorman

Status: Resolved

8. The number of PMs does not appear to cover all of the project objectives. There are no PMs for Oyster, seagrass, or connectivity. If the formulation possibly can, it would be good to have a PM link to each objective and then the monitoring plan could link to each PM. That way the project could be evaluated and assessed on the same parameters.

Response: Oysters and SAV are a part of PM1 and there is a connectivity PM - #9. We will add a table that links objectives to performance measures, and ultimately attributes being measured that can then be monitored as part of the monitoring and adaptive management plan. Subteam Leads: Patti Gorman and Andy LoSchiavo

Status: Resolved upon revisions to the document.

9. Include a section discussing the shift from mangroves back to the freshwater community and if the loss of mangroves will be a permitting issue.

Response: This can be added to PM#1, but there is no expectation that the mangroves will die off and be replaced by freshwater floodplain vegetation. Once established, mangroves have no problem living in freshwater. The only way to facilitate that shift back to a more historic vegetative community would be to actively remove the mangroves and plant freshwater species. That is not anticipated as part of this project. Prior planning coordination with FDEP indicated that changing conditions favorable to mangroves to restored condition favorable to Cypress floodplain would not be an issue. We are ultimately restoring unique plant community types that will improve overall system function and diversity in southeast Florida. Subteam Leads: Patti Gorman and Andy LoSchiavo

Status: Resolved upon revisions to the document.

10. Climate change is only mentioned 3 times in the document and sea level rise just once. A section discussing sea level rise and precipitation changes and how they will affect the future without and the alternatives is needed. Promoting resilience to climate change is a major white house priority

(Presidents Priority Agenda: Enhancing the Climate resilience of America's natural resources, October 2014).

Response: Agreed. Climate change is one of the moderate risks identified in the LRWRP risk register. A climate change analysis will be done to address SLR and whether precipitation changes are likely to be important factors affecting restoration performance. The effects of climate change will be measured using primarily PM 1. Climate change considerations will also be factored into the formulation of project alternatives with respect to storage. In addition, some management measures such as adjustable tide barriers strategically placed in the estuary are being considered during management measure development. The Climate change analysis will be a discrete section of the draft PIR and EIS. Subteam Leads: Andy LoSchiavo and Patti Gorman

Status: Resolved upon revisions to the document.

11. PM 1 mentions that "one of the guiding principles of the restoration plan is that one part of the watershed will not be sacrificed to benefit another part. It was essential to the restoration plan that ecological benefits were achieved system wide." Yet, many of the objectives state restore the various habitats and species as well as increase water supply. This does not seem possible with future population growth projections and climate change threats. A trade-off analysis that includes a water budget for the project area should to be performed.

Response: The discussion of restoration objectives related to water supply is summarized in the following excerpt from pg.18 of the Report Synopsis: "Ecosystem restoration is the primary goal, and formulation will first address ecosystem restoration objectives. Then, water supply benefits will be evaluated in reference to modeled operations of the recommended plan to optimize water supply performance, including increasing the amount of water made available by the project for consumptive use allocation in Lower East Coast Service Area without reducing the beneficial effects on the natural system." Subteam Leads: Patti Gorman and Andy LoSchiavo

Status: RECOVER scientists satisfied that the team will fully coordinate this with the USACE Vertical Team.

Review Part 3: Performance Measure Consistency with CERP

Performance Measure #1 – Seasonal Flows to Manage Salinity and Floodplain Hydroperiod in the Northwest Fork of the Loxahatchee River

Justification Section:

1. This section is confusing. What is supposed to be justified here? Is it the LRWRP itself, the VEC or the flow target from the Restoration Plan?

Response: All of the above, it sets the stage by discussing the historical, man-made changes that have caused damage. Then discusses the targets and selected VEC's. This section has been slightly rewritten to provide a clearer narrative on what and why we are measuring salinity related to VECs. Lead: Patti Gorman

Status: Resolved

2. Suggest that this section reiterate the goals of the LRWRP as stated in the project synopsis report, identify which goal (s) this PM addresses and concentrate on why the VEC, salinity envelopes and flow targets are appropriate for measuring progress towards these goals.

Response: We have added a written statement of LRWRP goals, objectives that relate to this performance measure that links the importance of flow and salinity to VECs in measuring the project goals. In addition, the VECs are consistent with the Loxahatchee River and Estuary CEM's ecological attributes. Lead: Patti Gorman

Status: Resolved

3. Paragraph 2 on page 2 needs a bit of rewording. In its present form it seems to indicate that opening of the inlet was a structural alteration that led to reduced freshwater inflow. One approach would be to re-write the paragraph to emphasize how structural alterations have led to saltwater intrusion.

Response: Paragraph rewritten to emphasize changes to the system that have led to saltwater intrusion. Lead: Patti Gorman

Status: Resolved

4. On pages 2 and 3, the discussion of the VECs, their location and their salinity envelopes could be improved by providing a more detailed description of how they were chosen and the relationships between location, salinity and the target flow scenario. For example, were the locations of the VEC chosen because this is where the flow target produced favorable salinity or does this reflect their present distribution in the river estuary?

Response: Language has been added to explain why VECs were chosen as good indicators of ecological community composition and health for the Loxahatchee River and Estuary and how they are consistent with ecological attributes described in the CEM for the Loxahatchee. Lead: Patti Gorman

Status: Resolved

5. Saltwater intrusion is not mentioned until the Evaluation target section and is only related to flow not water level. Was analysis performed to determine a minimum water level needed to correspond with the flow, or was it just assumed that the flow would provide the needed water levels?

Response: The restoration flows produce the right level of inundation in the Fresh water floodplain, but no analysis was done in the restoration plan to take into account a detailed analysis of how SLR will affect the water levels in the downstream portion of the floodplain. As part of the planning process, a SLR analysis will be done based on the USACE newest guidance. Lead: Patti Gorman

Status: Resolved

CERP Evaluation Target

1. The preferred restoration flow scenarios describe the LV90TV60, but later compare it to LV90TV90 and LV90TV120. The later scenarios are not explained and are very confusing. Suggest that a table that explains the scenarios be added or an explanation of the scenarios added. Include the table from the Restoration Plan since it is a key factor in the performance measure. The Floodplain Targets reference Figure 7 for LV90TV60, but there is no Figure 7 in the PM doc sheet.

Response: Label of Figure 7 has been changed to Figure 4. The performance measure figures will be edited and formatted consistently with the order they are introduced in the text. More information will be included on the three scenarios to simplify and clarify the modeling methods. Lead: Patti Gorman

Status: Resolved

2. Page 10: The document states that a conservative target of 1 psu was set in the Restoration plan for the freshwater tidal community upstream of RM 8.2. In Table 1 the target for the Upper Tidal Flood Plain is <2 psu. Why the difference? Are these two criteria considered compatible?

Response: Changed to <2psu

Status: Resolved

Evaluation Protocol

1. The target locations given in Table 1 do not entirely correspond to the locations given in the list of VECs in the Justification section.

Response: Good catch. The targets in the table will be matched up with the justification section. Lead: Patti Gorman

Status: Resolved

2. Locations of VEC overlap. This not necessarily a problem but it might affect scoring in some unforeseen way.

Response: We will index the scores for VECs where they overlap in area. The flood plain is separate from the river itself, so there is no overlap between riverine and upper tidal. *Valisneria* and fish larvae overlap from 10-6.5, so each would be ½ the score in that area. Fish larvae and oysters overlap for .5 miles, and oysters/seagrass for .5 miles. Lead: Patti Gorman

Status: Resolved. Updated description will be provided to RECOVER for courtesy review, ideally before project's model review takes place.

3. The protocol used to score the Riverine Floodplain VEC is pretty straight forward. However, as formulated the procedure might not be sensitive enough to distinguish between alternatives. For the two areas in the example given on page 11, an alternative that produced 5 months and 2 months

of inundation would also yield 328 habitat units. It might be better to have a more defined target inundation period of say 6 months. Anything with at least 6 months of inundation gets a 1. Five months gets (5/6=) 0.83, 4 months gets (4/6=) 0.66 etc.

Response: This is a good idea. We are pursuing a slightly different approach in making it more sensitive that brings in different time ranges for inundation and different scores that can be 1, .75, .5, and .25.

Lead: Patti Gorman

Status: Resolved

4. Riverine Floodplain: Is there an upper limit to inundation period. Would, for example, 10 months be too long and hence detrimental. Should a scoring protocol be developed for this eventuality?

Response: Yes, we looked into the detrimental duration anything longer than 8 months will start getting reduced scores that related to 1 additional month (9 months = .75), 2 additional months (10 months=.5), 11-12 months = .25, and anything greater is 0. Lead: Patti Gorman

Status: Resolved

5. Other VECs: No example is given. However, the scoring of habitat units for these would be likely based on the some measure of time that the salinity is within the preferred range at the preferred location(s). Compute mean monthly salinity in each 1 km segment from RM0 to RM16 for the period of record. Establish a target number of months each year that salinity should be in the preferred range for each VEC. For *Vallisneria* this would be 12 months each year. For fish larvae it may be only each month from March-June. For each segment within the spatial range of a VEC, compute the number of months during the relevant time of year that salinity is within the preferred range. For each segment, divide the observed number of months by the target number of months with the desired salinity range and multiply by the number of acres in the segment. Sum acres across segments within the desired spatial range for each VEC to calculate habitat units.

Response: Great idea. The Eco-subteam will coordinate with the reviewer (Peter Doering) to make revisions. Lead: Patti Gorman

Status: Resolved

6. How do you score the salinity targets? If the salinity is out of the range for the entire POR then it would score a 0, if it is in the range for the entire POR then it would score a 1. How does it score for being in range for part of the POR? Is it always 0.5 if it is one day less the than target?

Response: The team will further develop the degree of reduced scoring, either .5 or .25 increments, as is suggested for the inundation portion of the metric. Output will be focused on monthly averages, so 1 day less than target won't affect the score. However, a larger deviation from the salinity over a certain portion of time (7 to 15 days) could affect the monthly average and then the resulting score for an

alternative. Subteam Leads: Patti Gorman

Status: Resolved

7. It looks like the actual goal is to restore flows at Lainhart Dam and the salinity targets are based on flows. I would try to state that clearly at the start of the PM doc sheet, since flows are really the only thing the project is going to affect. Flows are the target, salinities result from the flows and the targets are based on salinities of the VECs.

Response: Text has been added to explain the link between flows at Lainhart Dam and other NW Fork Tributaries and downstream salinity, as well as inundation depth and duration in the river floodplain. Lead: Patti Gorman

Status: Resolved

8. Please give an example using one of the VECs, not just the riverine floodplain example. The VECs use the other models and are not just based on output from the hydrological model.

Response: Oysters have also been added as an example of using the salinity PM to measure performance for this VEC. Lead: Patti Gorman

Status: Resolved

9. Scoring system is not very sensitive, 1 month and 5 month meeting of the salinity score the same (0.5). There is a big ecological difference between meeting the target 1% of the time versus 99% of the time, but as it is written, both would receive a score of 0.5. There needs to be greater sensitivity in the scoring rubric.

Response: The team is currently considering how best of include additional increments of scoring related to salinity duration in months and area in which salinity ranges occur to provided scores of 0, .25, .5, .75, and 1. Lead: Patti Gorman

Status: Resolved

10. The LSMM was mentioned in 2 sentences with the second stating "This model can also simulate system operation rules and calculate the amount of freshwater demand for salinity management". There should be a description as to how this modeling tool will be used in the PM and the Evaluation methodology.

Response: This statement has been removed and replaced with an overview of the models being used and how they relate to model output specific to salinity and the VECs being evaluated. Lead: Patti Gorman

Status: Resolved

Performance Measure #4 – Hydrologic Regimes of Major Plant Communities in the Loxahatchee Watershed and Adjacent Wetlands

Justification Section:

1. The document states that a separate performance measure has been established for Grassy Waters Preserve. Is that performance measure being used for this project? Where is that PM doc sheet?

Response: We are correcting the statement to read: In addition, a separate evaluation criteria has been established for Grassy Waters Preserve (GWP) that accounts for Snail Kite use and water supply in addition to freshwater wetland plant communities. GWP is still evaluated as part of this PM for wetland plant community hydrology benefits. But, a separate evaluation criteria that looks at constraints related to the endangered Everglades Snail Kite habitat and use of GWP, as well as water supply benefits obtained from GWP. Subteam Lead: Andy LoSchiavo

Status: Resolved. Revisions will be sent to RECOVER.

Evaluation Protocol

1. When were the WRAP assessments completed? It reads as if they were done in 2004. If they are being used for the evaluation, should they be updated to assess current conditions?

Response: They were completed in 2004. We are making the assumption that the changes experienced in all sites will show some improvements and some degradation but will not be significant enough to affect the overall planning decision. There will only be a few site assessment updates to be able to understand the magnitude of these changes to provide data to substantiate the assumption. Subteam Lead: Andy LoSchiavo

Status: Resolved upon coordination with USACE vertical chain

2. Using the WRAP from 2004 makes the assumption that the 2004 assessment is the existing condition. If this is the case, this needs to be explained in the document.

Response: We will add this explanation to the document. See response above. Subteam Lead: Andy LoSchiavo

Status: Resolved

3. The Lower East Coast Sub-Regional Model (LECsR) was modified for this project study area and field measurements were used to confirm and update the current model. A brief overview of this activity and the effectiveness of the model/updates are needed here. The description of how the model will be used to predict and/or evaluate the success of the project is confusing. There seems to be a significant amount of data manipulation for the comparisons. Will the results be field verified?

Response: We will add more language on what model updates were made specifically. One key update was the elevation based on laser level measurements in the field when conducting WRAP assessments. This corrected the elevations used by the model. Subteam Leads: Andy LoSchiavo with Beth Kacvinsky and Boyd Gunsalus

Status: Resolved. Leads will make sure language is clear in the document and provide for courtesy review by RECOVER reviewers

4. How to use the WRAP analysis for alternatives was not well defined. The WRAP score is made up of 6 parameters: Wildlife utilization; Wetland overstory /shrub canopy; Wetland vegetative ground cover; Adjacent upland/wetland buffer; Field indicators of wetland hydrology; and Water quality input and treatment systems. The evaluation appears to focus on using a model for the field indicator of wetland hydrology and none of the other scores are described as to how they will be modeled. The WRAP procedure is probably not the best methodology to use for future without condition and the alternative evaluation due to it being primarily a field tool. Some sort of expert elicitation and models would be needed to use this tool for alternatives.

Response: Correct. WRAP is used for an initial assessment of the baseline conditions. In order to standardize the calculation of model derived WRAP scores from field assessed scores, LECsR model results for the existing conditions base were scaled to the Eco-Subteam's field scores for the hydrology component only. Alternatives and future without project predictions only compare hydrologic changes caused by the project and non-project actions. Hydrology is the dominant variable being affected by restoration alternatives, as well as the main limiting variable within the natural areas that will be restored and reconnected. Subteam Leads: Andy LoSchiavo, Boyd Gunsalus, and Inger Hansen

Status: Resolved. Revisions will be sent to RECOVER.

5. Table 11 for Pal Mar and Cypress Creek depict no difference among alternatives for the wet prairie. There may be a better community to use.

Response: The Table 11 comparing Pal Mar and Cypress Creek was used to illustrate how there are differences in inundation for several vegetation communities relative to hydroperiods targets. This table is now called Figure 4 in the revised performance measure documentation sheet. Based on the WRAP assessments and the Existing Conditions Base, the dominant vegetation community type will be used as the target to compared alternatives against. The assumption that as hydrology improves for the dominant vegetation (depression marsh for the Pal Mar and Cypress Creek sites), other vegetation community types are likely to either benefit or not get worse. If an evaluation area existing conditions hydrology already meets the target for the dominant vegetation (what we see with wet prairie in this example, but it isn't the dominant vegetation), then we shouldn't see any further improvement and wouldn't claim in restoration benefits. Subteam Leads: Andy LoSchiavo, Inger Hansen

Status: Resolved. Revisions will be sent to RECOVER.

Performance Measure #9 – Hydrologic/Spatial Connectivity

<u>CERP Evaluation Target</u>

1. The target is the highest % increase in connectivity. What is the CERP target? 100%, 90%, what are we shooting for? I can see evaluating and comparing the alternatives based on the highest % connectivity, but what is the end goal? What are we ultimately trying to achieve?

Response: There was not a CERP target evaluated for Loxahatchee with respect to connectivity. CERP looked at amount of canals and levees removed compared to each other over the current condition of 330 miles of canals and 400 miles of levees in the Everglades protection area. We are looking at connectivity relative to four criteria and maximizing the benefits of connectivity for natural area connection, hydrologic connection, water quality improvements, and endangered-threatened species improvement. We will clarify that the target for this performance measure is the first column of the Hydrologic/Spatial Connectivity Matrix: Target – 1. Connect hydrology between natural areas that promote additional flow to the Loxahatchee River; 2. Restoration actions promote connectivity (flow and land) consistent with an existing or proposed greenway corridor; 3. Connectivity actions promote flow of water only through natural overland flow; and 4. Connectivity contributes to expanded native habitats and support of wildlife populations by improving foraging range, territory, or migration path of listed or rare endemic species. Subteam Lead: Andy LoSchiavo, and PM9 team

Status: Resolved.

<u>Evaluation Protocol</u>

1. There is currently some connection to the NW Fork of the Loxahatchee, how would it score using your criterion rubric?

Response: Yes, there is some connectivity. From the standpoint of evaluating relative improvement among alternatives, the existing conditions will be used to represent a zero score, which is similar to how CERP evaluated connectivity in the Everglades Protection Area. We'll add this assumption to the documentation sheet. Subteam Leads: Andy LoSchiavo, Jerilyn Ashworth, and Delta Harris

Status: Resolved. Revisions will be sent to RECOVER.

2. If Existing condition is considered a zero, is future without project considered a zero as well? Could connectivity get worse than it is now?

Response: Yes, the future without is likely to be zero or slightly better. Connectivity realistically would only get worse if new roads, developments, levees were constructed in the publically owned lands. This is likely not going to happen in public lands. Connectivity could get better based on partners taking actions to restore connectivity. We are still in the process of reviewing future without assumptions and accounting for what projects are planned in the foreseeable future, and then accounting for their ability to provide more connections between natural areas. Subteam Leads: Andy LoSchiavo, Inger Hansen

Status: Resolved.

3. Scoring system is not very sensitive, partial connectivity always scores a 12.5. There is a big ecological difference between a 1% connectivity and a 99% connectivity, but as it is written, both would receive

a score of 12.5. There needs to be greater sensitivity in the scoring rubric.

Response: The commenter is correct that there are some varying degrees of measuring partial connectivity. The purely quantitative approach would calculate the mileage of canals and levees and then measure the amount of levees/canals removed. This approach would not accurately calculate the benefits of connectivity, when only a portion of the canals and levees really need to be opened up to achieve the benefits of connectivity. Where and how much of the total number of levee/canal removal is necessary to achieve full benefits for hydrology, greenway, water quality, and threatened/rare species is difficult to precisely determine. We opted for a more qualitative approach using best professional judgment and a standardized set of qualitative criteria supported by GIS results and various agency reports and scientific literature supporting each criteria. The approach allows for ratings of the four criteria (hydrology, greenway/blueway, water quality, and Threatened/rare species) that are split into thirds (0, 12.5, and 25). Theoretically, alternatives could have any variety of total scores (sum of all four criteria) ranging in 12.5 increments from 0-100. Subteam Leads: Jerilyn Ashworth and Andy LoSchiavo

Status: Resolved. Revisions will be sent to RECOVER.

4. How is this PM used to calculate habitat units? You get a score from the criterion rubric, but what is done with it from there?

Response: The team is still developing the benefits model. The approach used last time was to have the connectivity score be an index multiplied by the acreage of the natural areas where connectivity was improved by an alternative. The acreage was then further weighted to represent 10% of the total habitat units for the watershed, while PM 4 would represent 90% of the total habitat unit score for the watershed. We will likely use a similar approach but have not confirmed the portion PM9 will represent, whether 10% or up to 33%.

Status: Resolved. Revisions sent to RECOVER. Team will provide courtesy review to RECOVER for further input as team progresses.

5. The figures 3 and 4 have issues and especially the "Rare Species Potential Habitat" map is not helpful, impossible to sort out with background colors.

Response: We have updated these figures and will include the updates in the revised performance measure. Subteam Leads: Delta Harris and Marissa Krueger

Status: Resolved. Revisions will be sent to RECOVER.

6. It is unclear what would be done to establish the connectivity. Will properties be bought and converted to natural areas? Where and how much? Will canals be filled in? Will new canals/swales be constructed? Can the current topography be used to reestablish the connections?

Response: All of the above. A number of properties have been purchased already in public ownership. Primarily, the alternatives will focus on reconnecting and restoring some portion of those lands in public ownership. Ditches and canals will be plugged or filled. Berms and levees will be degraded in some areas to promote sheetflow/connectivity and reinforced in others to address flooding constraints. Some areas may be regraded. Other areas may include culverts and spreader canal to not only connect areas hydrologically, but to facilitated water movement across the landscape in a sheet flow form, while improving the timing and distribution of natural storage and flow to the river. Subteam Leads: Andy LoSchiavo

Status: Resolved.

7. It is also unclear how the connectivity is calculated. Mention of the alternatives such as "Future Without Project" imply that model output will be used. However, the descriptions are all of GIS layers and seem to only include potential land acquisitions or land type changes making it only a mapping exercise. If this is the case, the discussion of water quality (implied benefit of potential sheetflow) and flora and fauna seems misleading.

Response: It is a GIS based exercise. There are benefits of both hydrologic and land connectivity to reduce fragmentation for fish and wildlife. We will be clearer on what species will benefit from this type of connectivity. With respect to water quality, if connectivity brings water from natural area to other natural area, rather than natural area, to canal, to natural area, there will be more nutrient removal (wetland biogeochemical removal of excess nutrients because of more contact with vegetation) and less nutrient concentration (canal affects during dry season) (RECOVER, 2007). With respect to flora and fauna, benefits range from additional foraging area, breeding opportunities, increased genetic health/diversity, and additional habitat area for shelter and growth to adult (Smith, et al., 1996; Beier and Noss, 1998; Bond, 2003; Hoctor, et al., 2007). Subteam Lead: Inger Hansen

Status: Resolved.

E.11 RECOVER CONSISTENCY REVIEW: LRWRP ADAPTIVE MANAGEMENT AND MONITORING PLANS

In accordance with CERP Guidance Memorandum 40.02 and other relevant guidance (e.g., CERP Guidance Letter 12/06), RECOVER must review the Loxahatchee River Watershed Restoration Project (LRWRP) project level monitoring plan(s) in regards to consistency with the existing Monitoring and Assessment Plan (MAP 2009) to prevent duplication of monitoring activities. Additionally, in this review, RECOVER evaluates the need for project-level monitoring to fill temporal or spatial gaps for parameters monitored in the MAP 2009 in order to evaluate project-level effects. As projects are typically not at the construction stage when this Review is prepared, and that a variety of changes may occur between now and operational readiness of the Project, this review, when completed, should be considered an interim document. Future developments may require modification of monitoring plans and/or revision of this Review. This document provides RECOVER's comments and recommendations to the Project PDT regarding incorporation of proposed monitoring into the project.

As of the date of completion of this Annex, the Adaptive Management Plan and associated Monitoring Plans for LRWRP were not available for RECOVER review. This statement documents recognition that the

LRWRP Adaptive Management Plan and Monitoring Plans are in draft and will undergo updates in the future. It is recommended that a detailed review of the Adaptive Management Plan and Monitoring Plans be performed by RECOVER, when these documents are finalized, in order to gain input from scientists who possess most current system-wide scientific knowledge. RECOVER will continue coordination with the U.S. Army Corps of Engineers and the South Florida Water Management District as requested.

E.12 RECOVER REVIEW OF THE LRWRP DRAFT PROJECT OPERATING MANUAL (DPOM)

The 2003 CERP Programmatic Regulations (33 CFR Part 385.26(c)) provides for, but does not require, a RECOVER review of the Project Operating Manual. This statement documents recognition that the LRWRP operating manual is in draft and will undergo updates in the future. It is recommended that a detailed review of the DPOM be performed by RECOVER near the end of the project design phase, in order to gain input from scientists who possess most current system-wide scientific knowledge. RECOVER will continue coordination with the U.S. Army Corps of Engineers and the South Florida Water Management District during future LRWRP project operations manual updates as requested.